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MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

1926 Progress

Advances in mechanical engineering fields for the year 1926 are recorded in this issue in the Progress Reports of the Professional Divisions. The reader of these reports can place himself abreast of the times and may look forward with intelligent vision into the immediate future. Industry and the profession owe much to the authors of these comprehensive surveys.

DECEMBER 1926

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Mechanical Engineering

The Monthly Journal Published by

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* * * * *

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* * * * *

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* * * * *

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* * * * *

R. E. Peterson, in the motor-engineering department of Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., received his B.S. in mechanical engineering from the University of Illinois in 1925, and his M.S. in theoretical and applied mechanics from the same university in 1926. Mr. Peterson's paper is also a 1926 Student Prize paper.

* * * * *

B. H. Van Oot, since 1924, state supervisor of trade and industrial education, state of Virginia, received his B.S. and M.A. from Columbia University and has done post-graduate work at the University of Chicago. During his professional career he has been director of vocational education of the state of Maine, superintendent of St. George's Trade School, New York City, and professor of industrial education in the Virginia Polytechnic Institute. During the war he was in charge of the organization of vocational-training centers in the American Army in France.

* * * * *

E. D. Hall, superintendent of inspection development, Western Electric Co., Inc., has been associated with that concern for twenty years. Mr. Hall started his work as an equipment engineer in 1906, previous to that having been a draftsman. For six years he was a field engineer on communication projects and later was in charge of a division in the company's West Street laboratory, New York City. For three years he was in charge of testing all machine-switching central-office installations for that company. He is now in charge of inspection development.

* * * * *

R. A. Sherman is connected with the Fuel Section of the U. S. Bureau of Mines, in charge of the field investigation of research on boiler-furnace refractories. He was graduated from the State University of Iowa in 1920. **W. E. Rice** and **L. B. Berger,** co-authors with Mr. Sherman, hold the positions respectively of assistant engineer of the Pittsburgh Experiment Station, U. S. Bureau of Mines, and laboratory assistant.

H. W. Dickinson whose paper on Landmarks in the History of Prime Movers forms the leading article in this issue, is assistant to the director of the Science Museum, South Kensington, London, and is the honorary secretary of the Newcomen Society. He is well known both in this country and abroad for his activity and interest in museum work.

* * * * *

Progress and Prospects in Mechanical Engineering. On pages 1407–1434 of this issue appear the reports of the various Professional Divisions of the Society, reviewing in condensed form the progress in their respective fields during the past year. All of these reports are interesting, and each gives the latest word in the advance of science and art in its particular field.

As President Abbott says in his Foreword, "no great advances in human knowledge spring fully developed out of the ignorance of the past. They are the result of patiently adding one forward step today to yesterday's most advanced position; and although at some turn of the road a much clearer conception may be had of the location of the goal, its eventual attainment is as much due to the gropings of all of the previous yesterdays as to the more brilliant discoveries of today."

"To the members whose work on these Professional Divisions is gradually extending our scientific frontier," concludes the Foreword, "are due not only the thanks and appreciation of our own Society, but also of the whole engineering fraternity and of mankind as well."

Thurston and Towne Lectures to Be Important Features of Annual Meeting in New York, December 6 to 9

In these Lectures, established to present more clearly to engineers the results of scientific and economic investigation, and so auspiciously inaugurated last year, Dr. C. H. Lander, of London, is to set forth the latest discoveries in the chemistry of coal, while Prof. Davis R. Dewey, of the Massachusetts Institute of Technology, will discuss the credit factor in the structure of industry. They are to be delivered at hours not conflicting with those of sessions, and members attending the Meeting should arrange to hear these eminent authorities on fuel research and economics.

MECHANICAL ENGINEERING

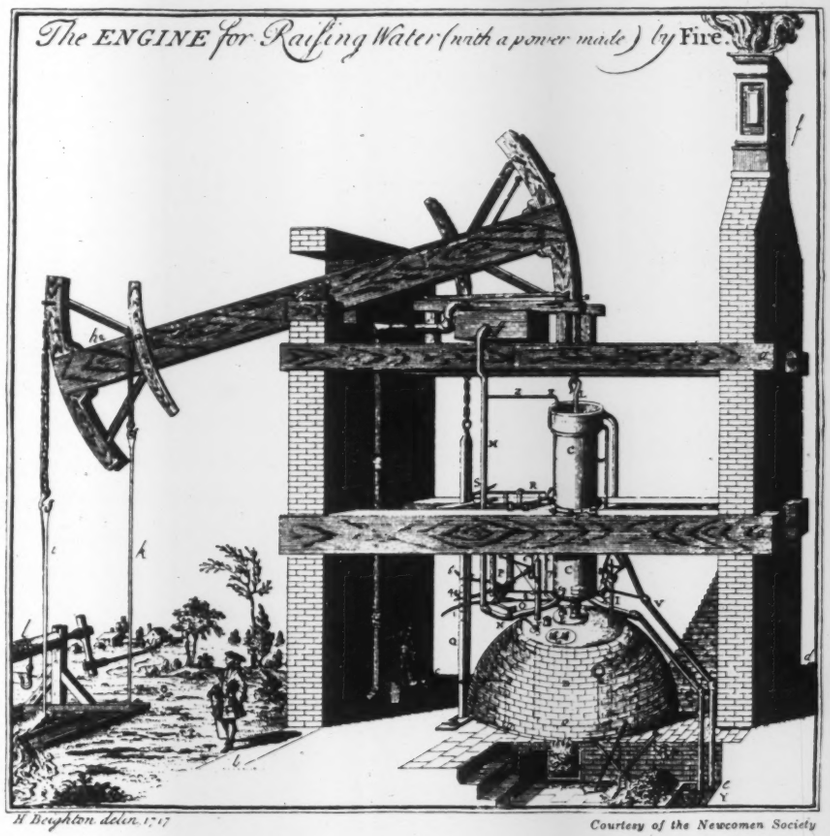
Volume 48 · December, 1926 · No. 12

Landmarks in the History of Prime Movers

By H. W. DICKINSON,[1] LONDON, ENGLAND

IT IS NOT the author's purpose to give a complete history of the development of prime movers. In the time at his disposal that were an impossible task, besides it has been done already many times by previous authors. He wishes rather to pick out the outstanding inventions or turning points in ideas that have led to such developments and thus prepare his hearers for what they will shortly see in the Museum. Please bear in mind always that just as *natura. . . .non facit saltum*, so inventions and ideas, although they advance apparently by jumps, are nevertheless the result of long previous excogitation.

To begin with, we must designate as the first prime movers man and the animals that he domesticated. Perhaps some one will tell the author whether they can be classed as heat engines, and if so how to explain their efficiency—which should be very low theoretically as their limits of temperature are extremely small. Domestication of animals and slavery of his fellow-man, much as the author regrets to have to say it, must be regarded as the first landmark. A servile state released the free man from the necessity of performing the more arduous tasks and permitted that leisure which enabled the few to prosecute the arts. Before any serious advance could take place, a long period had to elapse during which the concept of the mechanical powers and the idea of rotative motion (for nothing analogous existed on our earth) had their rise. These advances were probably the outcome in warm eastern countries of simple requirements such as the erection of buildings and the raising of water for irrigation.



"Atmospheric" Steam Engine as Perfected by Thomas Newcomen in 1712

The energy of flowing water had naturally been commonly experienced for thousands of years before it was harnessed as a prime mover in the form of the simple current or float wheel dipping into a stream. We first know with certainty of its being used during the first century B.C. in the Mediterranean area. Besides raising water, this wheel also replaced hand-labor in grinding corn. From this the development of the water wheel using the weight as well as the momentum of the water was only a matter of time. It might be observed that the period of greatest advance in its efficiency was at the beginning of the 19th century when enormous water wheels like that of Laxey, I.O.M., 70 feet in diameter, were erected, and new types like the Poncelet were invented.

The energy of the wind must have been experienced if anything more frequently than that of water, yet it was centuries later than the water wheel, if we except the sailing vessel, before it was brought into service of man. It was natural that this should be so because wind is inconstant and is of small power, so that the inventive and constructive skill needed to bring it under control was of a high order. The post mill in the simplest form appears in western Europe in the 12th century. It is thought to have come from the East, but whether it spread across Europe or whether the knowledge was brought in through the Arabs of Spain we are ignorant. The post mill had a vertical fixed post on which were grouped the wind shaft with its sails and the transmission to a pair of millstones—for its duty was practically always that of grinding corn. To get increased power meant longer sweeps, and these again meant greater height. This led to the smock mill, in which only the top and not the whole mill is turned into the wind. Reefing sails and the fantail for turning the mill automatically into the wind followed at the end of the 18th century. It is safe to say that nothing fundamental in the use of wind power except perhaps the Flettner rotor has since appeared.

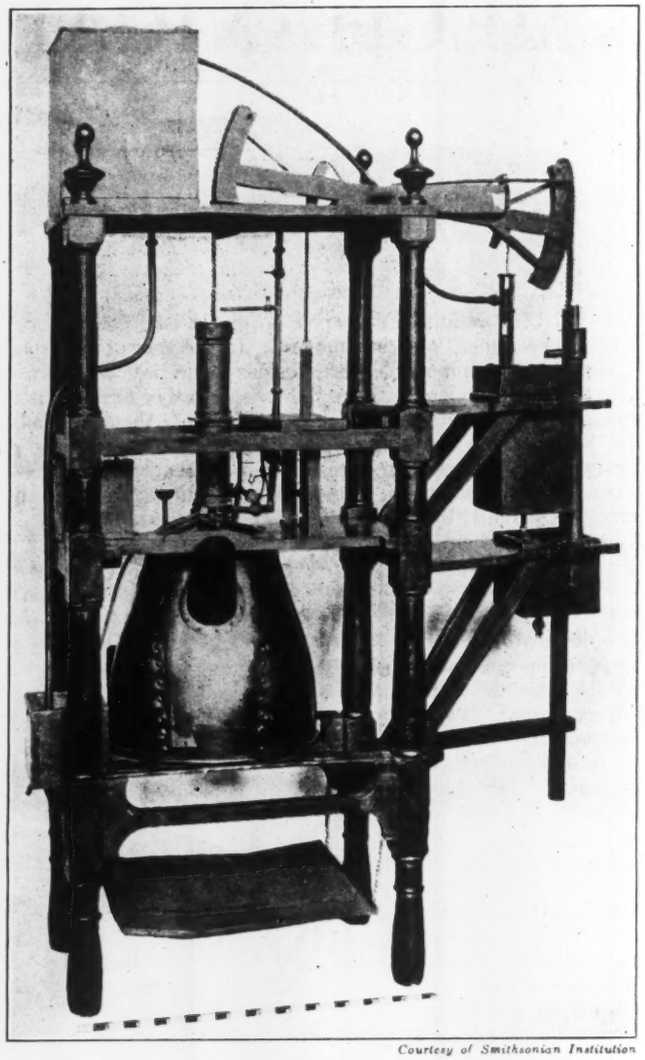
Let us now revert mentally for a moment to the Middle Ages and consider the line of thought likely to have been followed by a speculative mind, nourished on the time-honored Greek idea of the four elements—earth, air, fire, and water, and starting from the fact that air and water having been, as we have seen above, successfully harnessed, there remained earth and fire to be subdued. But in what direction was a solution to be found? Since the discovery of fire, fuel had been burnt for cooking, warmth, and, as time went on, for industrial purposes; fuel had been used to heat air and liquids, and if done in closed vessels it was known that striking effects could be obtained. The writings of Hero, of Alexandria, shows that they

[1] Honorary Secretary, The Newcomen Society for the Study of the History of Engineering and Technology.

Paper presented at a meeting of the Society of Engineers at the Science Museum, South Kensington, London, May 3, 1926.

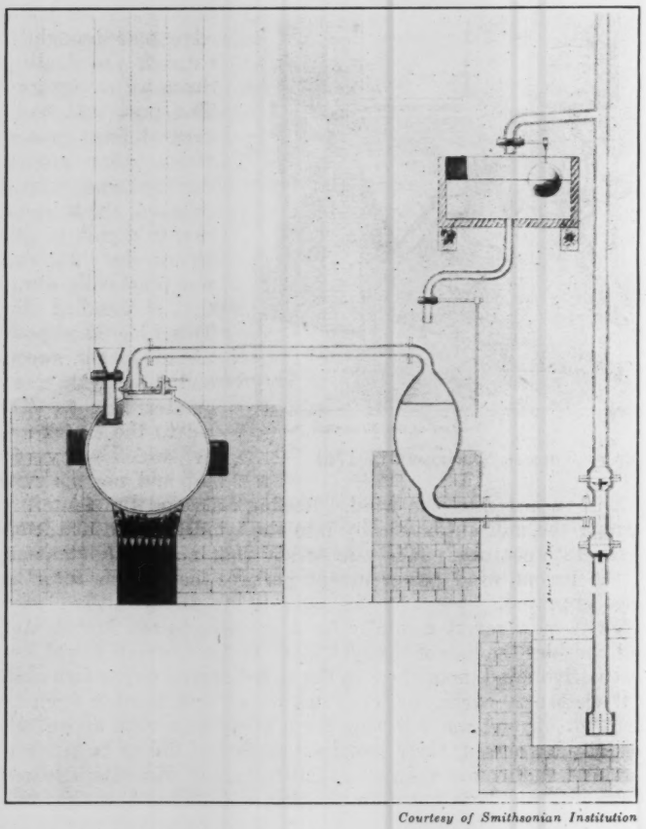
Courtesy of Smithsonian Institution

Hero's Aeolipile, About 50 A.D. Model Shown Was Built at the Smithsonian Institution, Washington, D. C.



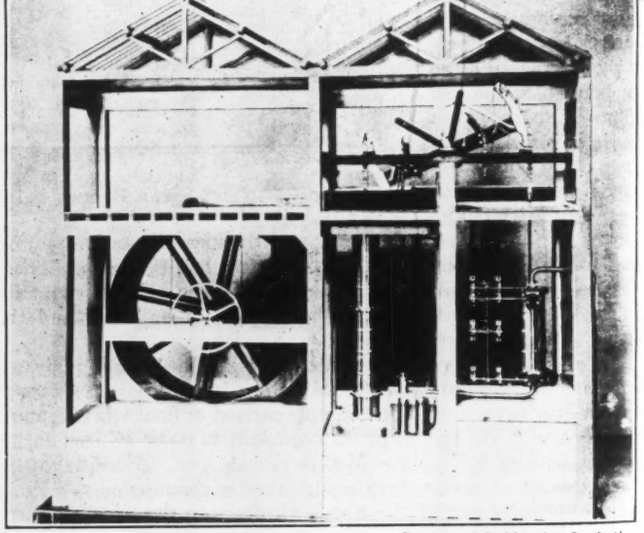
Courtesy of Smithsonian Institution

Working Model of Newcomen Engine Used at Edinburgh University and Repaired by James Watt in 1763. This Inspired Watt's Invention of the Separate Condenser in 1765. Original Is now in Science Museum, South Kensington



Courtesy of Smithsonian Institution

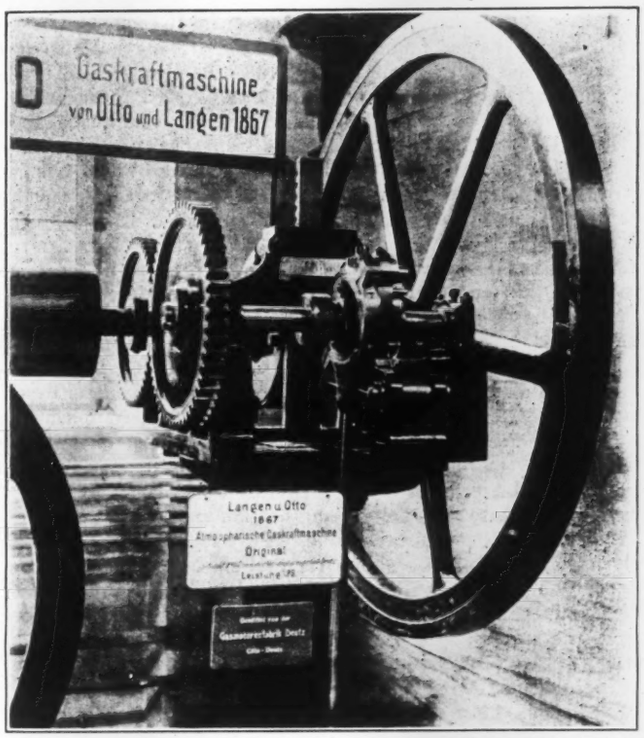
Thomas Savery's "Atmospheric" Steam Engine, Patented in 1698, as Described by Him in an Address Before the Royal Society of London in 1699



Courtesy of Smithsonian Institution

Working Model of James Watt's "Old Bess," Now in the Science Museum, South Kensington, Shows General Arrangement of the Original Engine Erected in 1777 at Boulton's Manufactory, Soho, to Which It Furnished Power Through the Medium of a Water Wheel

were used to mystify the credulous in classical times. The fact is that the task was one of enormous difficulty because, unlike the case of wind and water, *molecular* changes were involved. Hence, a long period had to elapse to enable considerable advances in knowledge to be made before any forward step could be visualized. Such were the studies of the philosophers Galileo and Torricelli in the 17th century, who showed that the atmosphere had weight



Courtesy of Museum of Peaceful Arts

COMPRESSION GAS ENGINE OF LANGEN AND OTTO, BUILT IN 1867, AND NOW IN THE DEUTSCHES MUSEUM, MUNICH

and explained the fact, then well known, that a pump will not suck water beyond about 28 feet in depth.

Thomas Savery, F.R.S., the most prolific inventor of his day, in 1698 patented his "fire engine" in which he embodied two ideas: one was to condense steam in a vessel communicating with water, when the latter would rise and could be retained by a non-return valve; the other was to force up this water by the direct pressure of steam on its surface. The operations could be repeated indefinitely by working suitable valves, for it will be observed that the ideas involved are those of the pulsometer of today. Alas for Savery, the mechanics of his day—the blacksmith, plumber, and carpenter—were not equal to the task of making vessels that would stand the considerable pressures involved. His engine was nearly 200 years before its time!

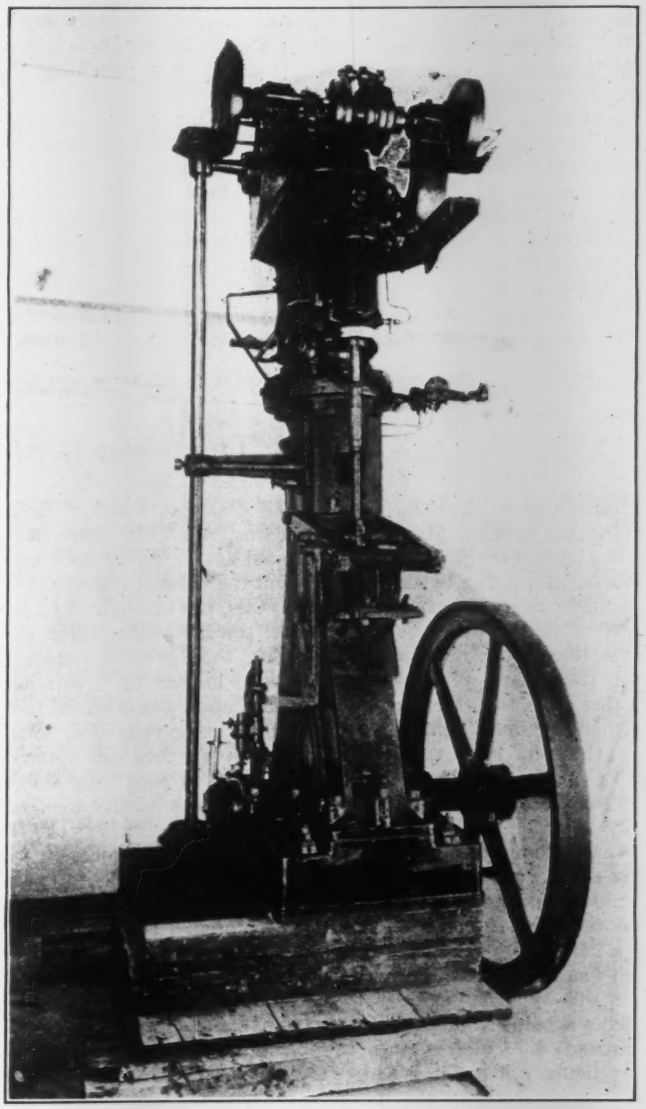
Meanwhile Thomas Newcomen had succeeded by 1712 in perfecting the "atmospheric" engine which is the progenitor of the modern steam engine. Without doubt Newcomen's engine is a landmark of the first order in the field that we are investigating. Newcomen adopted the cylinder and piston; he hit upon the idea of condensing steam under the piston; he schemed a way of getting rid of the condensed water and entrained air; he connected the piston rod by a chain to a giant pump handle or lever, on which the pump rods were hung; and finally he made the engine repeat its movements automatically. The great point to be observed is that no pressure higher than that of the atmosphere had to be provided for; hence the construction was within the capabilities of the mechanics of the time. This is a condition, be it observed, that limits invention all through technical history.

The atmospheric engine held sway for half a century till James Watt in 1763 had the brilliant inspiration of condensing the steam in a vessel which was separate from the cylinder. This is another outstanding landmark, for at one bound the fuel consumption was halved.

Twelve years of experiment and disappointment elapsed before Watt was able to joint the "princely" Matthew Boulton in the celebrated partnership which gave Watt the opportunity and time to bring the engine into public use.

Watt's next step was to employ his engine for obtaining rotative motion. Debarred by a patent from using the crank and connecting rod, he invented several substitutes and one—the sun-and-planet gear—was used till the expiration of the patent. He doubled the power of the engine by making it double-acting; this necessitated a positive connection, instead of the chain, between the piston rod and the beam, but he completely solved this difficulty by his invention of the parallel motion in 1784. Henceforward the engine ceased to be merely an apparatus for raising water and entered upon the worldwide sphere of a universal stationary engine—the greatest landmark of all in the history of prime movers.

The engine was still a vacuum apparatus, however, till in 1802 Richard Trevithick, the great Cornishman, patented the high-pressure engine, i.e., he used steam at a pressure above atmospheric and dispensed with the vacuum. The simplification that resulted made possible a compact, self-contained, and cheap motor that could be adapted to practically any purpose. No one was quicker to see



Courtesy of Museum of Peaceful Arts

THE FIRST DIESEL ENGINE, PATENTED IN 1892 AND 1895, AND BUILT IN 1897. NOW IN THE DEUTSCHES MUSEUM, MUNICH

this than the inventor himself, and in 1803 he applied the engine to locomotive purposes. This experiment inaugurated the era of mechanical land transport by road and rail—a subject to which it is impossible to do justice within the limits of this paper.

We must now pause to glance at what was being done with water power, for as remarked above, no fundamental improvement took place in windmills. The crude and efficient Barker's mill or reaction wheel was developed by Benôit Fourneyron in 1827 into the pressure turbine in which multiple fixed curved vanes direct the water on to corresponding moving vanes which so change the direction of motion of the water that its energy is absorbed. This was a landmark of the first magnitude in that it has opened out the vast field for experiment and research in utilizing falls above the limits of a water wheel. The continued advance in size and in closeness of speed regulation has been very marked, and turbines of 50,000 hp. are now common.

A parallel development is afforded by the case of the simple impulse wheel provided with buckets on its periphery on which impinge one or more jets of water at high pressure. Dividing the bucket to split the jet, the invention of L. A. Pelton in 1878, greatly increased the efficiency, hence his name is usually associated with the motor. Governing has since been the great problem, but so successfully has it been done that such wheels are used for the most exacting service.

Harking back to the heat engine, the landmark that we have to note next is the introduction by N. A. Otto in 1866 of the compression gas engine, the culmination of the labors of inventors over a period of 70 years. This opened out a great field of activity not only in scheming different cycles of operation and regulating the mixture of gas and oil, but also in the use of other fuels for combustion, such as high-flash oil and gasoline for engines. This introduced a further complication—viz., the necessity of gasifying or vaporizing the fuel before combustion. The hot bulb for oil and the carburetor in its innumberable forms for gasoline have been the means adopted to this end. Still another device is that of spraying the fuel—crude oil—into pure air at the end of the compression stroke, as patented by Akroyd Stuart in 1890 and Rudolf Diesel in 1892, whence much development has taken place.

The coming of the gas engine and its rapid development seemed as if it was going to elbow out the steam engine; in fact Sir Frederick Bramwell at the British Association in 1881 said: "However much we may today contemplate with regret even the most distant prospect of the steam engine's becoming a thing of the past, I very much doubt whether those who meet here fifty years hence will then speak of that motor except in the character of a curiosity to be found in a museum." Within three short years of this prophecy, however, the steam turbine was brought out by the Hon. Sir Charles Parsons, who thus set up another landmark in the history that we are tracing. The steam acts, not by pressure as in the reciprocating engine, but by change of momentum, and it is evident that, just as in the case of the water turbine, there must be two general types, viz., the reaction and the impulse turbines. The Parsons turbine is of the former type, while the impulse turbine is due to the labors of Dr. C. G. P. de Laval of Sweden in 1889. The turning point in the progress of the steam turbine was reached by Parsons two years later—in 1891—when by making it condensing it equaled in efficiency, and later with larger units surpassed, the reciprocating engine.

There have been many turbines brought out since, under different names, but critically examined they will be found to belong either to one or the other type or to be a combination of both. One of these, however, must be mentioned—that of Birger Ljungström, 1906—which has two sets of blades running in opposite directions and takes off power from both shafts; needless to say great practical difficulties had to be overcome to accomplish this. The rapid increase within the last decade in the size of units, accompanied by marked reduction in weight for unit power and the recent great increase in boiler pressures that has taken place, tempts us to state that here is another landmark.

Yet after all that has been done, we are faced with the fact we only have been able to obtain a thermal efficiency of less than 40 per cent, and that each successive per cent has meant much greater effort than the last. We feel that we have nothing to boast about, rather the reverse, so that it is small wonder that many eyes are turned toward a new source of power of which we have the first inkling, that of the energy of the atom.

The French Motor Car of Today

THE October 15, 1926, issue of *The Engineer*, London, in an article entitled Motor Cars in Paris, comments interestingly on the latest French motor cars exhibited at the Salon de l'Automobile. According to the correspondent the striking improvements one might naturally expect after two years, the time since the last previous Salon, were not in evidence, the impression being that while there were refinements of details, there was no departure from the general principles which guided makers two years ago. At that time, says the correspondent, attention was centered more particularly upon light engines of high angular velocities. Since then the behavior of those engines has been watched with interest, for obviously there is nothing to be gained in producing a light and small engine if its life is to be shortened by excessive wear and tear.

Apart from the question of lightness, the main object in running engines at very high speeds was to create types of small nominal horsepower for the purpose of taxation and yet provide motorists with as much power as they required. There will always be a fairly large class of motorists who are attracted by the small high-speed engine with rapid acceleration, and there is no doubt that this type of engine will continue to be developed until it reaches a point where it will permanently influence the design and construction of motors suitable for the ordinary user. The $1^1/_2$-liter engine, which will give more than 100 horsepower, is a remarkable achievement of the motor builder, and many engines now made are wonderful examples of what can be done nowadays in a specialized branch of engineering. Nevertheless, while admiring these products of the motor engineer, the average automobilist is still skeptical regarding their durability and economy. There is a decided tendency to attach more importance to the solidity and efficiency of a motor than to its weight, and in the Paris Show the engines were mostly of the $1^1/_2$- to 2-liter class, with everything simplified and rendered as compact as possible. The single power unit is still in favor, and there appear to be fewer cars in which the engine and gear box are separate. Overhead valves are becoming more general on account of the higher speeds at which the engines are run, and they also have an advantage in giving a cleaner appearance to the engine, which externally, is characterized by severe simplicity. The four-cylinder engine is still predominant, but the desire for flexibility is giving more importance to six-cylinder and even to eight-cylinder engines, which are either straight or V-shaped. There is no new departure in the engines themselves. The improvements made are to be seen almost entirely in points of detail.

In the chassis there is the same absence of any real novelty. Attempts are made to improve design by compromise, and more attention is given to such details as suspensions, steering gears, and brakes. The keynote of the situation apparently is comfort and security.

Improvements are usually costly and have to be embodied in car design when the public requires them, such as, for example, the four-wheel brakes, but there are other improvements of a valuable character which can only be adapted to expensive cars.

It may be remarked also that while endeavoring to simplify design the French maker has not found it prudent to sacrifice either material or workmanship on the score of price, and the tendency that was observable two or three years ago toward the production of cheap cars has not materialized, except, of course, in the case of a small number of firms who specialize in the mass production of popular cars.

The small cheap cars are not profitable to the maker nor, generally, to the user. There are, nevertheless, a number of small firms who continue to turn out light and cheap chassis. *The Engineer*, October 15, 1926, p. 420.

Refractories

An Investigation of Boiler-Furnace Conditions as Related to Refractories Service[1]

By RALPH A. SHERMAN,[2] W. E. RICE,[3] and L. B. BERGER,[4] PITTSBURGH, PA.

THE investigation of the proper application of boiler furnace refractories being conducted by the Bureau of Mines in coöperation with the Special Boiler Furnace Refractories Research Committee of the A.S.M.E. is now in the second phase of the program—namely, the experimental analysis of the factors governing the life of the refractories. The purpose of this phase of the investigation is to provide the user, the manufacturer, and the ceramic engineers engaged on the problem more accurate information than has heretofore been available in regard to the conditions met by the refractories in service.

The data obtained will be of value in so far as they can be used in the laboratory as a guide for the determination of the effect of different conditions or combinations of conditions on a given refractory, or of the effect of conditions on different refractories. The experimental investigation is therefore an important step in the entire program which has for its ultimate purpose the lowering of the cost of boiler furnace maintenance.

The purpose of this report is to present an outline of the conditions which are thought significant and which are being analyzed, the methods being used, and certain of the data obtained up to the present time which may be of general interest.

Illinois Coal on Traveling Grates

The two principal causes of refractories' failure in furnaces burning Illinois coal on traveling grates are slag erosion and spalling. The spalling is generally confined to the arch, while slag erosion is found in all parts of the furnace lining.

The furnace conditions which were considered significant and which are being investigated are as follows:

1 The temperature and rate of change of temperature of the refractories
2 The furnace-gas temperature
3 The furnace-gas composition, including SO_2 and SO_3 content
4 The velocity of the furnace gases
5 The chemical and mineralogical composition and the quantity of the slag carried in the gases.

These conditions have been studied, as they occur in actual operation in a furnace at the Fisk Street Station of the Commonwealth Edison Company at Chicago. The furnace selected was under a boiler having 11,500 sq. ft. of heating surface and fired with two forced-draft stokers having a total effective grate area of 278 sq. ft. It was equipped with a suspended arch in which there were two rows of air ports, the front of four, the rear of five, for the admission of over-fire air by natural draft. The openings were regulated by tiles on top of the arch. The front four were open during all tests. The furnace volume was 2585 cu. ft. This furnace was selected on the advice of the company engineers as representing the average severity of service among the boilers of all their stations. A section of the furnace showing the holes through which gas temperatures and samples were taken is given in Fig. 1.

Coal

Kincaid coal was burned during the tests. A representative analysis follows:

Moisture, per cent	13.5
Volatile matter, per cent	34.4
Fixed carbon, per cent	39.9
Ash, per cent	12.2
Sulphur (separately determined), per cent	3.4
Calorific value, B.t.u. per lb	10,480
Softening temperature of ash, deg. fahr	1,960

[1] Published by permission of the Director, United States Bureau of Mines.
[2] Assistant Physicist, Pittsburgh Experiment Station, United States Bureau of Mines.
[3] Assistant Engineer, Pittsburgh Experiment Station, United States Bureau of Mines.
[4] Laboratory Assistant, Pittsburgh Experiment Station, United States Bureau of Mines.

Refractories Temperatures

It is desirable to know the normal and maximum temperatures which occur on the surface of the refractories in the various parts of the furnace from the standpoint of slag erosion, and to know the rate of change of temperature with time at the surface from the standpoint of spalling. It is possible in a furnace of this type to see but a small part of the walls to read the temperatures with an optical pyrometer, and the liabilities of error with this type of instrument in a smoke-filled furnace are well known. It is impossible to place thermocouples directly on the surface of the refractory and secure readings for more than a very limited period as the couple will be destroyed by the heat, the gases, and the slags. The method adopted was to place a series of couples at various distances from the hot face in arch blocks, bridgewall blocks, and standard bricks at selected parts of the furnace. Continuous readings of these temperatures were made by means of a multi-point recorder over an extended period of time while the boiler was operated in accordance with usual station practice. These temperatures have been plotted in curves but are not given here as they are too large for publication.

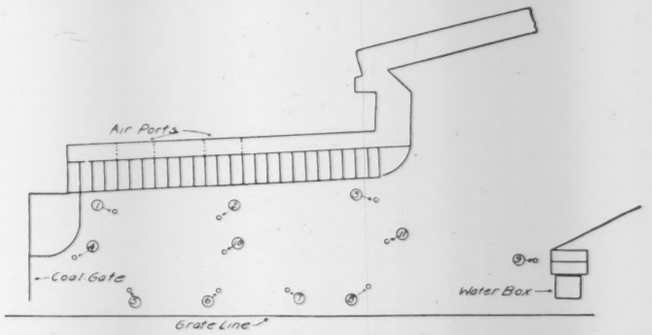


Fig. 1 Section of Furnace Showing Positions for Sampling Gases and Measuring Gas Temperatures—Fisk Street Station, Commonwealth Edison Company

From these temperature readings at various distances from the hot face the gradient through the piece may be plotted, and by extrapolation the furnace temperature may be determined with a fair degree of accuracy. Such extrapolated temperatures may vary from the true temperature in so far as the surface temperature may fluctuate over a limited period without these fluctuations becoming apparent at $^1/_2$ or 1 in. from the surface. It is these surface fluctuations which are undoubtedly of importance in spalling, and the attempt is being made to place couples very near the hot surface. Platinum couples are necessary for such determination, and the number that may be installed is therefore limited.

The temperature gradients through several of the pieces in this furnace at 5 hours after lighting the fire under the cold boiler are given in Fig. 2. The maximum temperatures read in various parts of the furnace during 4 days of operation as determined by extrapolation of the temperature gradients, together with the maximum and minimum temperature of the furnace gases near these points, are given in Table 1. The refractories temperature is generally higher than the average gas temperature and very close to the maximum gas temperature, indicating that the temperature of the fuel bed or of the gases at some distance away was the factor determining the temperature of the refractory rather than the temperature of the gases at the surface.

Furnace-Gas Temperature and Composition

The temperature and composition of the furnace gases just inside the wall at the various positions shown in Fig. 1 as determined during normal operation of the boiler at loads of approximately 70,000 to 77,000 lb. of steam per hour are shown in Fig. 3. The

temperatures are highest in the upper part of the furnace, though not greatly lower halfway between the arch and the grate. The temperatures are higher just above the grate than might be expected from the low CO_2 content which is due to the air coming

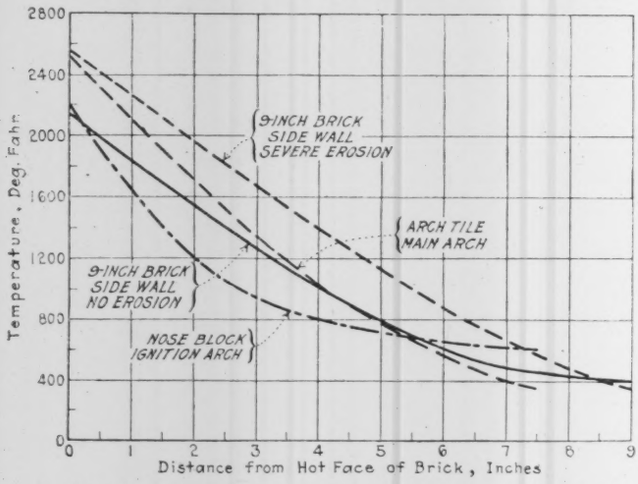


FIG. 2 TEMPERATURE GRADIENT THROUGH REFRACTORIES IN CHAIN-GRATE-STOKER-FIRED FURNACE—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

through the slightly spaced bricks above the ledge plate. The temperatures read here are probably somewhat higher than the true gas temperature owing to the proximity of the couple to the fuel bed and the probable radiation to the junction of the couple. No CO or H_2 appears in the front of the furnace, but as much as 4 per cent occurred in one sample halfway between the front and rear.

Fig. 4 shows the variation in the temperature and composition of the gases from the side wall approximately halfway across the furnace at Position 2 which is halfway from the front to the rear and Position 3 which is near the nose of the main arch. These readings were taken at boiler loads of from 70,000 to 75,000 lb. of steam per hour. The O_2 content of the gases is omitted from these curves to avoid confusion. The CO_2 content decreases sharply at 3 ft. from the side wall with one exception at Position 3, while the temperature curves drop somewhat at two feet from the wall. The first air port at the front of the furnace is approximately three feet from the side wall and the decrease in CO_2 content is probably owing to the air from this port. This is not so clearly marked at Position 2, probably on account of the fact that this hole is at a greater distance below the arch, owing to outside piping, and the air from the port passes above it. The CO is high at the side wall and again in the center of the furnace, reaching a maximum of 8 per cent in one sample at Position 3.

SO_2 AND SO_3 IN FURNACE GASES

The determination of the SO_2 and SO_3 in the gases is not difficult but involves final determination in the laboratory and cannot therefore be repeated as quickly and as often as those gases which are determined by analysis in an Orsat apparatus. Table 2 gives the complete analysis of several samples taken at a distance of seven inches from the side wall of the furnace.

The maximum SO_2 content is 0.10 per cent and the maximum SO_3 content is 0.08

TABLE 1 COMPARISON OF MAXIMUM TEMPERATURE OF REFRACTORY WITH TEMPERATURE OF FURNACE GASES NEAR REFRACTORY PIECE—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

Position No.	Location	Maximum surface temp., deg. fahr.	Gas Temperature Average	Gas Temperature Maximum	Gas Temperature Minimum
1	Nose tile. Center of ignition arch	2100	2000	2250	1650
2	Arch block. Center in middle of arch	2500	2270	2370	2100
3	Arch block. Center—2 ft. from nose of main arch	2600	2450	2630	2300
4	Arch block. Side of arch 2 ft. from nose of main arch	2600–2800	2530	2750	2350
5	Nose block. Center of nose of main arch	2600	2550	2690	2325
6	Nose block. Side of nose of main arch	2500	2690	2830	2615
7	Bridge wall. Block center of bridge wall	2500–2600	2182	2570	1850
9	9-in. brick. Front of side wall. Slight erosion	2300	2080	2750	1675
10	9-in. brick in side wall. Great erosion	2700	2370	2900	2080

TABLE 2 GAS ANALYSES SHOWING SULPHUR CONTENT—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

Position	Grams per cu. ft. SO_2	Grams per cu. ft. SO_3	Complete gas analysis, per cent by volume SO_2	SO_3	CO_2	O_2	CO	H_2	N_2
2	0.0412	0.0191	0.06	0.02	15.3	0.4	2.1	1.1	81.0
2	0.0489	0.0223	0.07	0.02	12.7	4.9	0.0	0.0	82.3
2	0.0632	0.0324	0.09	0.04	13.9	3.3	0.5	0.3	81.9
3	0.0245	0.0551	0.03	0.06	4.5	13.1	0.0	0.0	82.3
3	0.0342	0.0717	0.05	0.08	10.3	3.6	0.2	0.0	85.8
3	0.0681	0.0180	0.10	0.02	14.3	3.7	0.0	0.0	81.9
10	0.0552	0.0204	0.08	0.02	14.4	3.0	0.0	0.0	82.5
10	0.0756	0.0147	0.10	0.02	14.4	2.5	0.5	0.0	82.5
10	0.0636	0.0231	0.09	0.03	13.7	0.7	5.6	2.3	77.6
11	0.0226	0.0289	0.03	0.03	8.3	11.2	0.0	0.0	80.4
11	0.0472	0.0057	0.07	0.01	10.5	2.3	7.6	2.5	77.6

per cent. The SO_2 content is greater than the SO_3 content except in two of the samples taken at Position 3, near the nose of the main arch, where the SO_3 is approximately twice as great as the

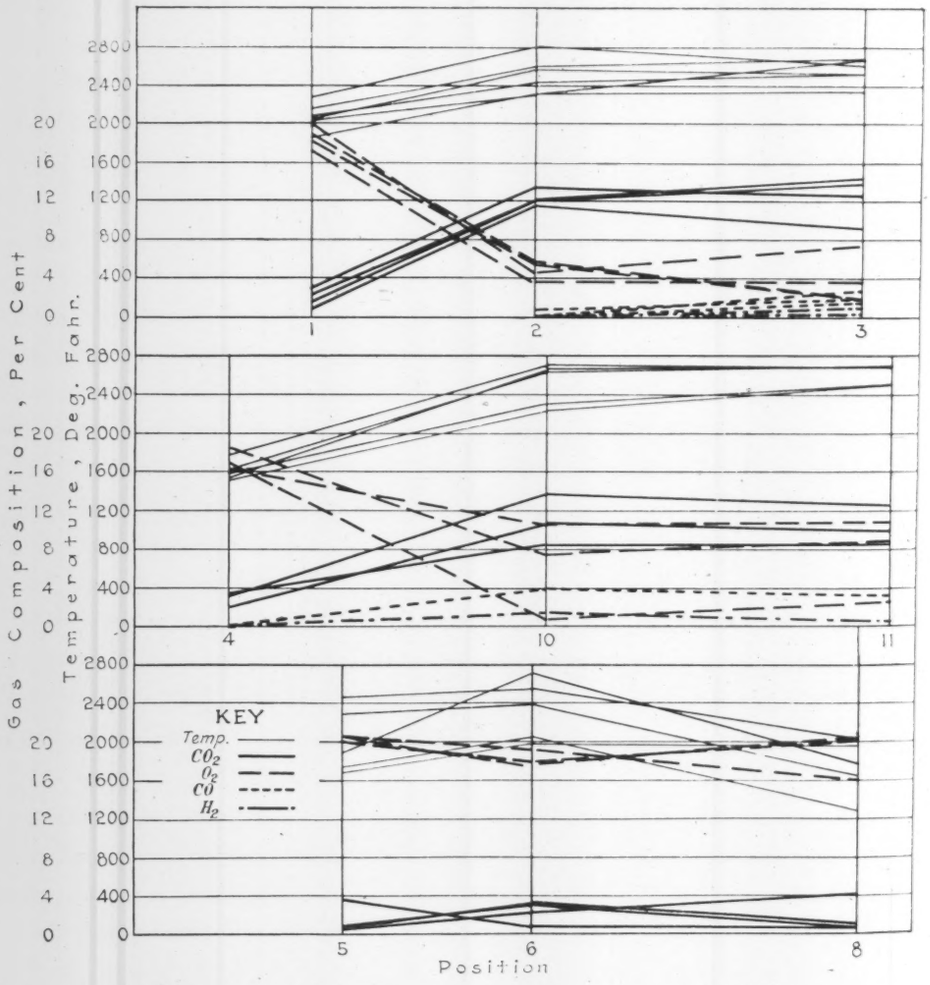


FIG. 3 GAS COMPOSITION AND TEMPERATURE AT SIDE WALL, CHAIN-GRATE-STOKER-FIRED FURNACE—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

SO_2. This coincides with the zone of maximum gas temperature.

The ratio of the SO_3 to the SO_2 formed in the reaction,

$$SO_2 + {}^1/_2O_2 \rightleftarrows SO_3$$

is expressed as

$$\frac{SO_3}{SO_2} = K\sqrt{O_2}.$$

K varies with the temperature, having a value 31.3 at 982 deg. fahr. and 0.012 at 2732 deg. fahr. when the concentration of oxygen is expressed in atmospheres' partial pressure. If the oxygen content of the gases is 5 per cent by volume, the maximum SO_3/SO_2 ratios with an ideal catalyst would be 7 at 982 and 0.002 at 2732 deg. fahr.

If sulphur is primarily released from the coal as SO_2 and conforms in its oxidation to the equilibrium constants there should be practically no SO_3 present in the gases at the temperatures of the boiler furnace. The SO_3 which was found here and when burning Pittsburgh coal on chain grates[5] may have been formed at the lower temperatures of the sampling tube.

The total sulphur content of the gases expressed as SO_2 or SO_3 is correct, however, and in consideration of the lack of information on the effects of the two oxides of sulphur on the refractories, this is probably sufficient for the needs of the present investigation.

TABLE 3—COMPOSITION OF SLAG AND COAL ASH SAMPLES—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

Sample No.	Remarks	Moisture	Loss on Ignition	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	Sulphur as SO_3	TiO_2
4	Slag from boiler tubes. Material next to tube	0.3	....	33.2	15.7	23.7	1.7	5.6	0.7	4.6	3.9	6.6	0.8
5	Slag from boiler tubes. Material on outside of pieces.	0.0	....	40.5	16.4	22.7	7.3	6.8	1.0	1.9	1.5	0.2	0.9
23	Slag from sampling tube at Position 11. 0–18 in. from wall	0.0	0.2	36.8	13.1	14.7	16.9	6.3	0.4	5.2[1]		6.4	...
24	Slag from sampling tube at Position 11. 18–36 in. from wall	0.0	2.1	41.2	14.6	9.8	19.5	7.9	0.7	1.9[1]		2.3	...
25	Slag from sampling tube at Position 8. 0–36 in. from wall	0.0	2.6	41.0	13.4	2.9	23.9	6.3	0.5	0.6[1]		8.0	0.8
26	Slag collected in collector through rear air port in fire arch	5.9	45.2	16.1	4.4	8.7[2]		7.1	0.5	11.8[1]		[3]	0.3
26	Moisture and combustible free	...	....	32.9	9.0	17.8[2]		14.5	1.0	24.2[1]		...	0.6
6	Coal	...	....	46.5	20.4[4]	19.8	....	5.1	0.6	3.6[1]		4.0	...
28	Coal	...	....	43.5	18.1	18.0	....	8.1	0.5	3.2[1]		8.6	...

[1] Alkali (by difference). [2] Total Fe_2O_3 and FeO taken together. [3] Not sufficient sample to determine SO_3. [4] Al_2O_3 contains any TiO_2 or P_2O_5 that may be present.

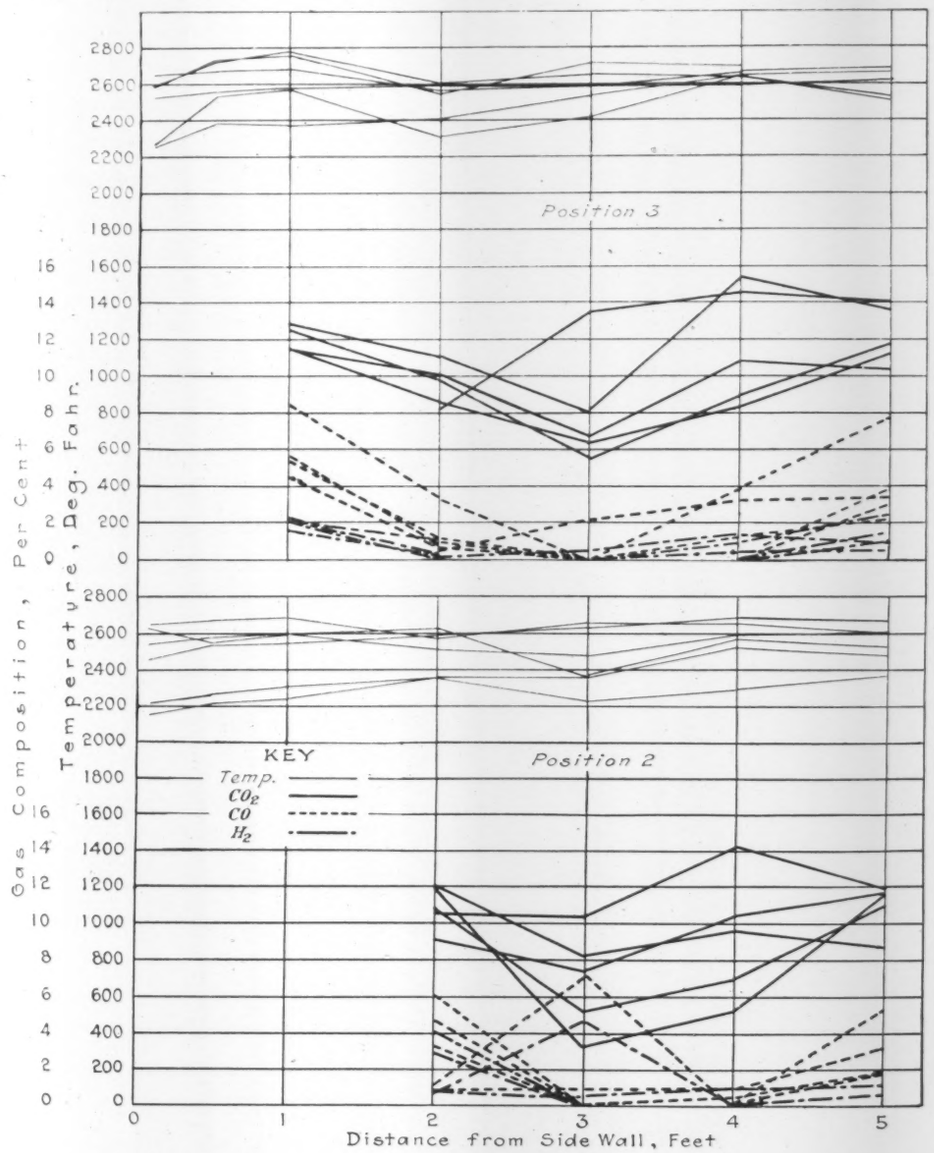


FIG. 4 GAS COMPOSITION AND TEMPERATURE ACROSS FURNACE, CHAIN-GRATE-STOKER-FIRED FURNACE—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

GAS VELOCITIES

The velocity of the gases in the furnace is considered of importance since the greater their velocity the greater will be their carrying power for slags and the more slag they will carry to the wall in a given time. Also, the greater will be their tendency to sweep the combination of slag and refractory from the wall, exposing fresh surface for attack.

The velocities were determined by means of a water-cooled pitot tube. The values just inside the wall from front to rear of the arch, just below the arch, and halfway between the arch and the grate are shown in Fig. 5. The maximum velocity is about 40 ft. per sec. at the nose of the arch.

The variation in the velocity of the gases from side wall to the center of the furnace is shown in Fig. 6. The maximum velocity is found at from 2 to 3 ft. from the side wall and is 50 ft. per sec.

SLAG COMPOSITION

It is of utmost importance in a study of the slagging of refractories to know the composition of the slag which is carried in the gases and may be deposited on the refractories. The composition of the coal ash itself is very easily determined, but since the ash is not uniformly distributed throughout the coal in pieces of uniform size, and since some compounds are more or less volatile, there is every reason to believe that the compositions of the ash carried in the gases and that remaining on the grates might differ.

Samples have been collected from the slag which adheres to the lower row of boiler tubes and from the slag which collects on water-cooled gas sampling tubes when left in the furnace for an extended period. A slag collector was designed consisting of a water-cooled tube with an enlarged receptacle at the end which could be turned

[5] MECHANICAL ENGINEERING, November, 1926, pp., 1115–1122.

to face the gas stream, and in which was placed an alundum thimble to collect the suspended material from the gases as they passed through by means of a reduced pressure maintained in the tube.

The analyses of some of the samples obtained in these ways are given in Table 3, together with the analyses of two typical ash samples.

The silica and alumina contents are lower and the total iron content generally higher in the slag samples than in the coal ash samples.

The alkalis are much higher in the slag next to the boiler tube than in that on the outside of the pieces. This indicates that the alkalis were in a volatile form which condensed on the comparatively

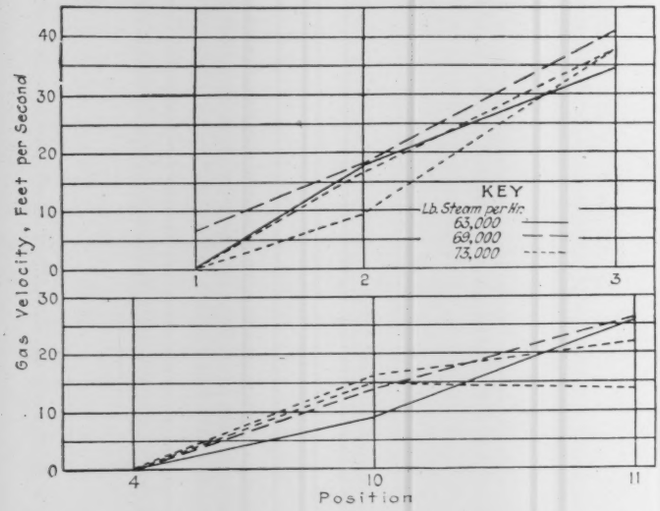


FIG. 5 GAS VELOCITIES AT SIDE WALL, CHAIN-GRATE-STOKER-FIRED FURNACE—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

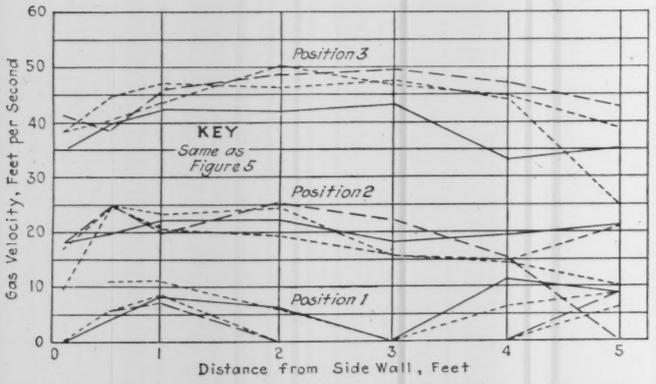


FIG. 6 GAS VELOCITIES ACROSS FURNACE, CHAIN-GRATE-STOKER-FIRED FURNACE—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

cool surface of the boiler tubes but did not remain on the outer material which was at a much higher temperature. The sulphur also remained in the material next to the tube but did not enter or was driven off from the outer material.

The preponderance of the ferrous over the ferric oxide will be noted in the samples collected on the sampling tubes. This is particularly marked in the sample from Position 8, where the temperature is high and the atmosphere generally reducing.

The composition of sample 26, collected in the special slag collector, shows considerable variation from that of the other samples. It contained 45 per cent of combustible matter, presumably soot, as it was collected near the ignition zone of the furnace. The silica-alumina ratio is much higher in this sample and the alkalis and sulphur are very high. Since the material is immediately cooled and kept cool in this method of sampling, while in the other method it is kept in contact with the hot gases, there should be no opportunity for change in composition and the sample should represent very closely the actual composition of the material as it occurs in the gases. Further work is being done with this method of sampling.

GROOVING OF ARCHES

Fig. 7 shows the interior of the furnace in which these studies were made. The left side wall was new two weeks before, the right wall had had about three months' service, and the greater part of the arch, including the center portion which is so deeply grooved, was new two weeks before. The erosion in this groove continued at such a rate during the ensuing two weeks' run that this portion was renewed.

At the time this was observed all the conditions which might cause such accelerated erosion were considered. They are:

1 Abnormal velocity of gases causing an increased rate of deposition of the slag
2 Higher temperature
3 Reducing atmosphere.

The surveys made at that time did not indicate that either 2 or 3 was responsible. In fact, the temperature in the center of the arch was somewhat lower than at the side.

The investigation of furnace conditions was continued after the grooved tiles were renewed. Fig. 8 shows the condition of the furnace at the end of 4 weeks after the portion inclosed in white lines had been removed. The erosion continued but more uniformly across the arch and the grooving did not recur during the following three months the furnace was under observation.

It is entirely possible that this grooving was owing to an increased velocity of gases at this position or to a reducing atmosphere due to some cause which was unknowingly removed before the gas velocity and composition surveys given above were made. These did not show higher velocity nor more reducing atmosphere than at the sides.

It has been found by conference with a number of operators that grooving of arches by erosion is a more or less familiar phenomenon. It is variously ascribed to obstruction of air by plates under the stoker, to streams of air directed by baffles in the air duct, and to segregation of coarse and fine coal by fantail coal chutes. In some cases the removal of one or more of these causes has been reported to have eliminated the difficulty. Another method of elimination of erosion which does not, however, strike at the primary cause, was advanced as having been successful in numerous instances. This is the restriction of the gas passage in the first pass by extending the baffle in line with the erosion on the arch, thus presumably causing more of the gases, with their slag, to pass to the sides of the grooved portion.

SPALLING

Reference to Fig. 8 shows little spalling on that portion of the arch in the near foreground which had been in service but two weeks. But in Fig. 8 there is considerable spalling evident in this area. The surface on the pieces was very probably changed owing to the prolonged heat treatment or to the absorption of slag.

Samples of new pieces and others after varying periods of heating are in the hands of the ceramic engineers, together with the data on the temperatures and rate of change of temperature, and from this material they should be able to draw some useful conclusions regarding spalling.

EASTERN BITUMINOUS COALS ON UNDERFEED STOKERS

The principal difficulty with refractories in underfeed stoker-fired furnaces burning eastern bituminous coals is the adhesion to the walls of slag from the coal ash. This slag builds out on the front and side walls reducing the grate surface and obstructing the movement of the fuel. The accumulation on the bridge wall causes bridging of the slag and clinker over the dump plates.

If the softening temperature of the ash is low or the furnace temperatures are extremely high, owing to high ratings or low excess air, the slag may become so fluid as to erode the front and side walls. It is also generally accepted that a reducing atmosphere will favor slag erosion.

Two furnace accessories are commonly used for the purpose of lessening the difficulty with slag. They are (1) inclined side-wall tuyeres or air backs, and (2) ventilated refractory blocks.

The inclined side-wall tuyeres consist of cast-iron sections or plates which fit over or replace the ordinary half-tuyeres along the side wall and are inclined toward the wall. The area of the air

openings may be the same or greater than that of the tuyeres which they replace. Since these tuyeres extend to a greater height on the wall than the horizontal tuyeres, they reduce the area of refractories exposed to slag action. The depth of fuel above them will also be less and hence the excess air above the bed at the wall may possibly be greater and the temperature lower than with the horizontal tuyeres.

The ventilated blocks consist of refractory shapes with several holes through which air passes into the furnace from a duct in the wall connected to the main air duct. They may be set in the bridgewall, side wall, or front wall. The air passing through the blocks absorbs heat, thus lowering the temperature of the block. The air entering the furnace will maintain an oxidizing atmosphere at the surface and may prevent the impingement of the flame on the walls.

OBJECT OF INVESTIGATION

The object of this investigation was to analyze the refractories service conditions in this type of boiler furnace and to determine the effect of inclined side-wall tuyeres and ventilated blocks on these conditions.

The furnace studied was one of the 44 of similar type in the Sherman Creek station of the United Electric Light & Power Co., New York City. The furnace had 672 cu. ft. of combustion space, and the boiler 6250 sq. ft. of heating surface. The projected exposed area of the boiler tubes in the furnace was 98 sq. ft. The furnace was fired with a 7-retort underfeed stoker, having a horizontal projected area of 98 sq. ft.

FIG. 8 CONDITION OF FURNACE AT END OF FOUR WEEKS—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

These furnaces were normally equipped with low inclined side-wall tuyeres, and ventilated blocks in the front wall, side walls, and bridgewall. A sectional view of the furnace is shown in Fig. 9.

Furnace conditions were investigated with solid brick walls and horizontal half-tuyeres at the side wall; with solid brick walls and low inclined side-wall tuyeres; with high inclined side-wall tuyeres; and with the combination of ventilated blocks and the low side-wall tuyeres.

No attempt was made to secure other than normal station combustion conditions during the test.

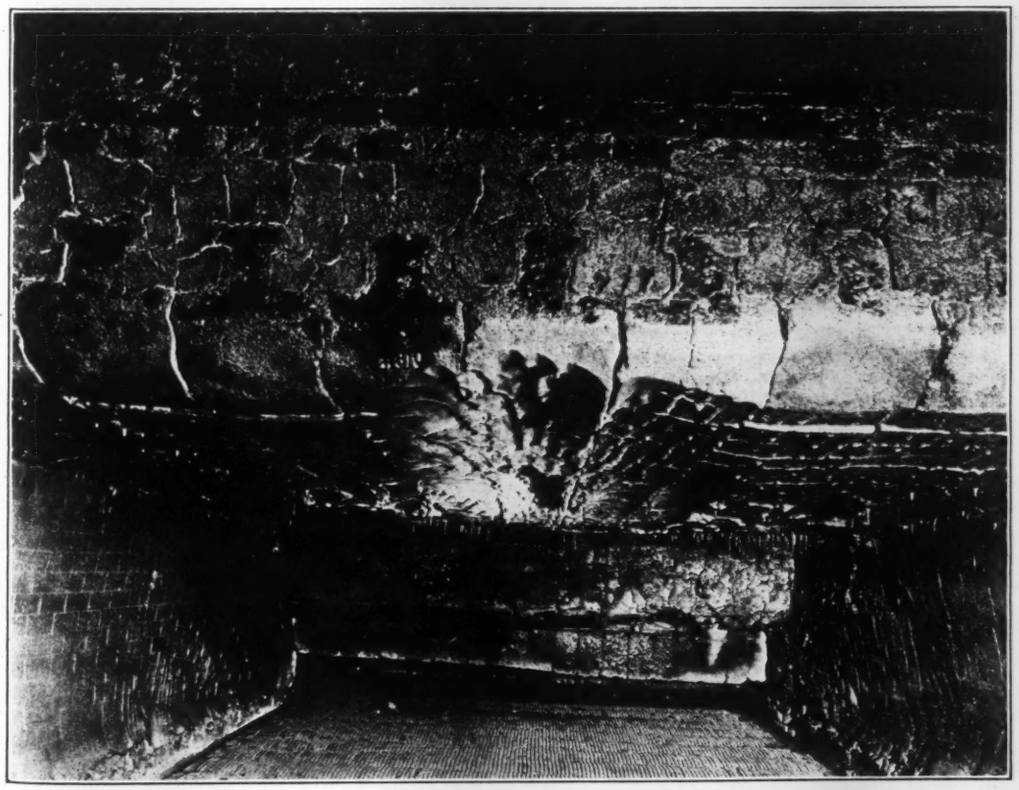


FIG. 7 INTERIOR OF FURNACE USED IN TESTS—FISK STREET STATION, COMMONWEALTH EDISON COMPANY

COAL

The coal burned during the investigation was that normally used in the station.

A typical analysis follows:

	Per cent
Moisture	3.8
Volatile matter	20.0
Fixed carbon	70.2
Ash	6.0
Hydrogen	4.7
Carbon	81.0
Nitrogen	1.2
Oxygen	6.5
Sulphur	0.6
Calorific value, B.t.u. per lb.	14,160

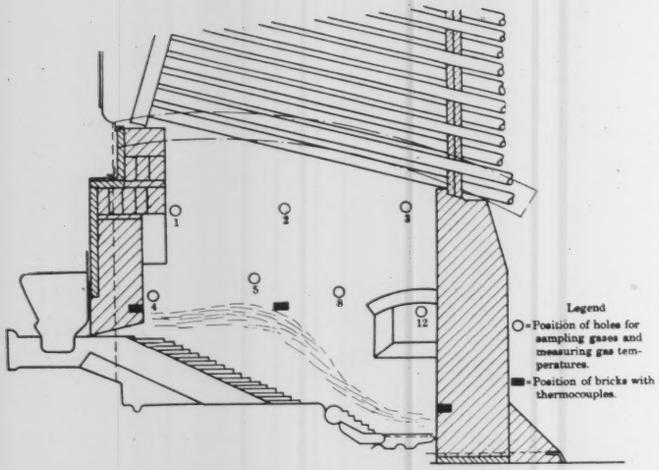


FIG. 9 SECTIONAL VIEW OF FURNACE SHOWING POSITIONS OF SAMPLE HOLES AND THERMOCOUPLES—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

REFRACTORIES TEMPERATURES

Temperatures were measured at various depths at several places in both the solid brick walls and the ventilated blocks over extended periods of time. Temperature gradients through some of the pieces at 10 to 12 hours after firing are given in Fig. 10. The temperature at the surface of the ventilated block is higher than in the standard brick in the corresponding position with solid brick walls, partly owing to a higher rating on the boiler at this time, and partly owing to the fact that the first thermocouple, though 1 in. from the plane face of the brick, was less than 1 in. from the surface of the vertical grooves in the block and the temperature was therefore higher at this point than it would have been had the block not been grooved. The temperature gradient through the ventilated block is steeper than through the solid bricks owing to cooling by the air.

The inner temperature of the 9-in. brick in the side wall with the ventilated blocks is low owing, no doubt, to cooling by air leaking through the wall from the air duct back of the blocks.

The temperature near the face of the ventilated blocks reached a maximum about 12 hours after the fires were lighted and then decreased constantly although the boiler rating was fairly constant. This was particularly marked in the block below the surface of the fuel bed, where the temperature 1 in. from the hot face decreased to less than 100 deg. When the slag was sliced off the wall at the regular cleaning period the temperature increased rapidly for several hours and again decreased up to the time of the next slicing period.

This decrease in temperature was obviously owing to the accumulation of slag, chilled by the air, on the face of the wall, keeping the hot fuel bed and gases away from the wall and to the cooling by air passing through it.

FURNACE-GAS TEMPERATURE AND COMPOSITION

The temperature and composition of the gases at the side walls, using the different equipment, are shown graphically in Fig. 11.

The high tuyeres have no marked effect on the difference between gas temperatures or excess air at the surface of the side wall and 24 in. from the wall as compared with the curve for the solid brick walls. With one exception, of the reading at 200 per cent of rating,

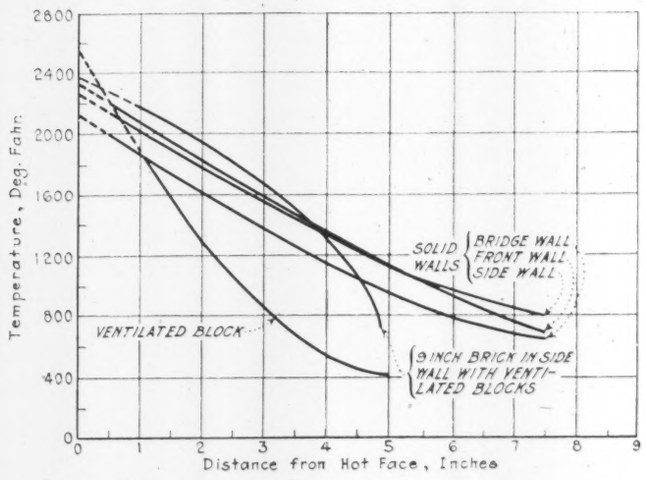


FIG. 10 TEMPERATURE GRADIENTS THROUGH BRICKS IN UNDERFEED-STOKER-FIRED FURNACE—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

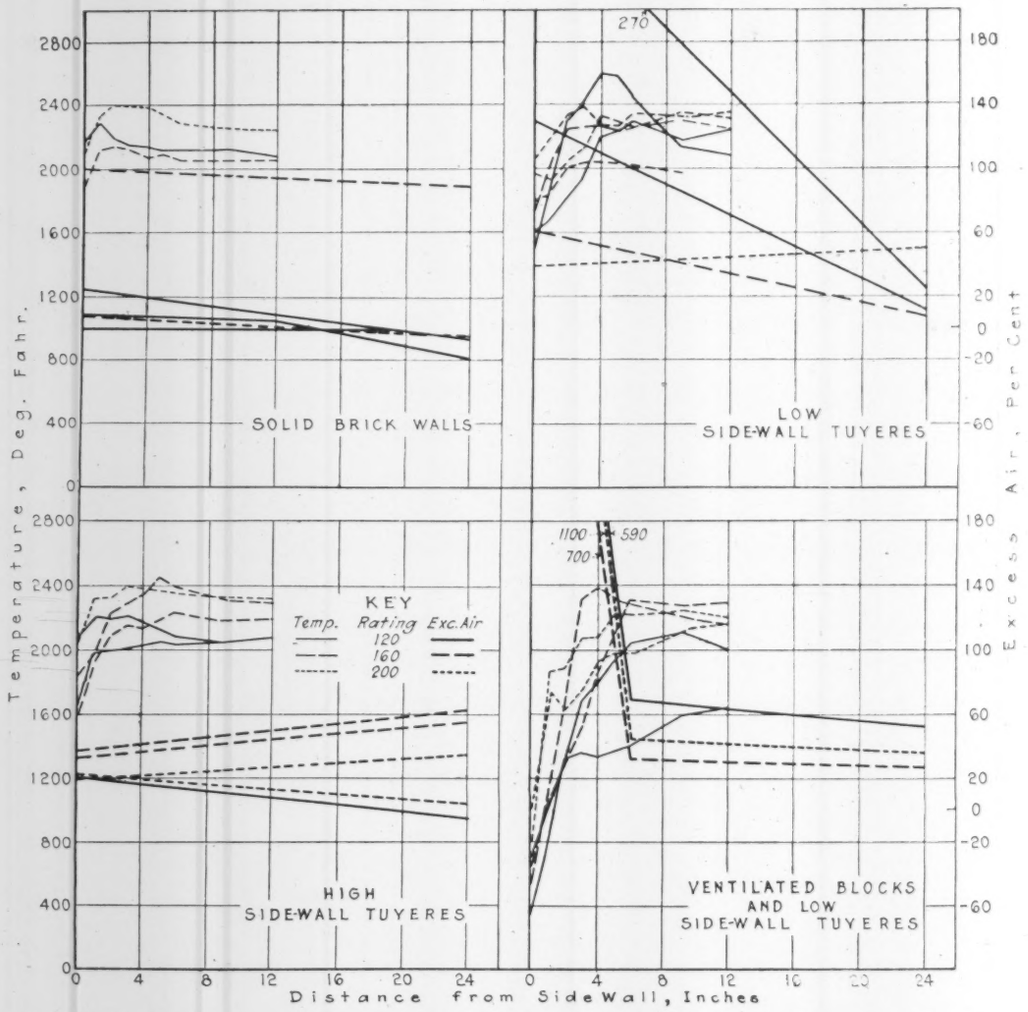


FIG. 11 GAS TEMPERATURE AND COMPOSITION AT SIDE WALL, UNDERFEED-STOKER-FIRED FURNACE—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

the excess air is considerably higher at the side wall with the low tuyeres.

The arrangement of the high tuyeres is shown in Fig. 12 and of the low tuyeres and ventilated blocks in Fig. 13. The area of the air openings in a set, for one wall, of the ordinary horizontal tuyeres and of the high inclined tuyeres is 17 sq. in., while of the low tuyeres is 25 sq. in. or approximately 50 per cent greater. This probably accounts for the greater excess air at the side wall with these tuyeres. The excess air at the wall surface with the ventilated blocks in the side wall is from 600 to 1100 per cent and the gas temperatures but from 400 to 800 deg. The excess air at 6 in. from the wall is not higher than normal with other equipment. It is probable that the greater part of the air from the blocks did not penetrate far into the furnace but passed up along the wall.

The temperatures and compositions of the gases at 24 in. from the side wall for the solid brick walls and the ventilated blocks are shown in Fig. 14. This figure shows the great stratification of the gases from the front to the rear of the furnace, even just below the tubes, and shows, incidentally, that some combustion must take place among the tubes. There is normally an excess of air at the front wall with the ventilated blocks rather than a deficiency, but there is no effect in the middle of the furnace. The excess air at the rear wall is less with the ventilated blocks than with the solid walls. This can scarcely be attributed to the ventilated blocks and might be owing to longer fires carried during these runs.

The temperature curves are, in general, the converse of the excess-air curves. There is no general relation between the temperatures and the rating. That is, the gas temperature at one position does not necessarily increase with the ratings. This is owing to the fact that the deficiency or excess of air also greatly affects the gas temperature, but, since the temperature readings and gas samples were not taken simultaneously, the exact cause of a particular high- or low-temperature reading cannot be traced.

Fig. 15 shows the gas temperature and excess air along the front wall, with a solid wall and with the ventilated blocks. The underfeed stokers under observation had fuel beds the surfaces of which were made up of a series of hills and valleys from side wall to side wall. From a theoretical standpoint it might be expected that the temperature and excess-air curves would follow a similar series of hills and valleys. It is clearly evident that they do not although they are quite irregular from side to side.

The excess-air readings are higher with the ventilated blocks,

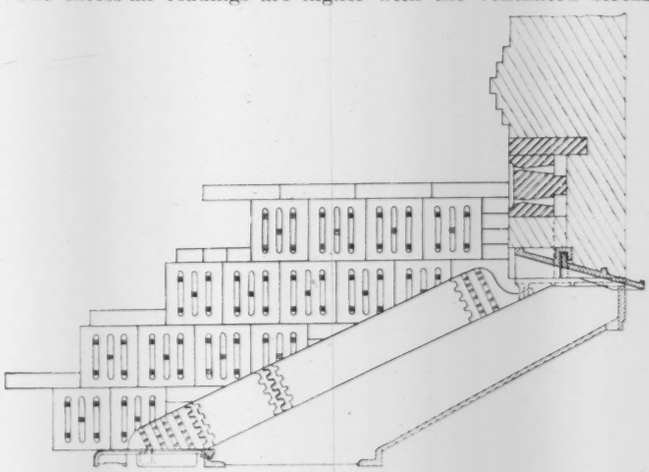


FIG. 13 LOW SIDE-WALL TUYERES AND VENTILATED BLOCKS—UNDERFEED-STOKER-FIRED FURNACE—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

particularly directly at the side wall, than with the solid walls. The gas temperatures are also particularly low at the side wall with ventilated blocks but not appreciably lower from 12 in. on. The gas temperatures are lower than the theoretical maximum because of a deficiency of air with the solid walls and because of an excess of air with the ventilated blocks.

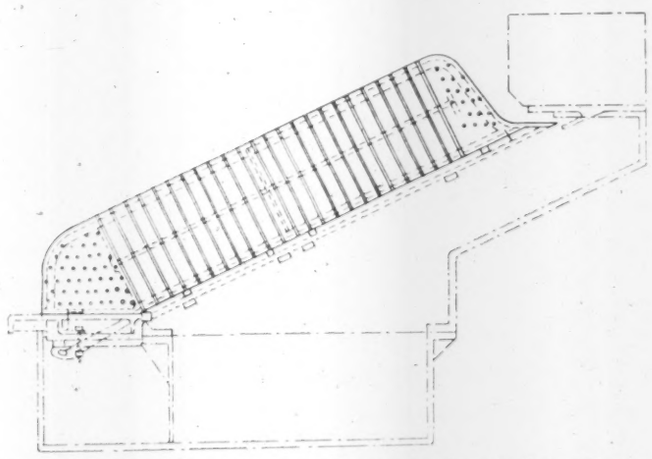


FIG. 12 HIGH SIDE-WALL TUYERES—UNDERFEED-STOKER-FIRED FURNACE—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

COMPOSITION OF COAL ASH AND FURNACE SLAGS

The composition of the coal ash from three composite samples made up from a number of separate coal samples taken during these tests follows:

	1	2	3
Silica (SiO_2)	53.2	53.4	51.8
Alumina (Al_2O_3)	27.9	29.0	27.6
Ferric oxide (Fe_2O_3)	9.7	9.3	9.8
Calcium oxide (CaO)	2.9	2.4	3.4
Magnesium oxide (MgO)	1.8	1.5	1.8
Silica-alumina ratio	1.90	1.84	1.88

The softening temperatures of these ashes ranged from 2340 to 2530 deg. fahr.

An attempt was made to sample the ash or slag particles directly from the stream of gases in the furnace, but with the apparatus devised at that time the attempt was not successful. As a compromise samples of slag were taken from the walls of the furnace when cold, care being taken to prevent the admixture of pieces of refractory. The composition of these samples is given in Table 4.

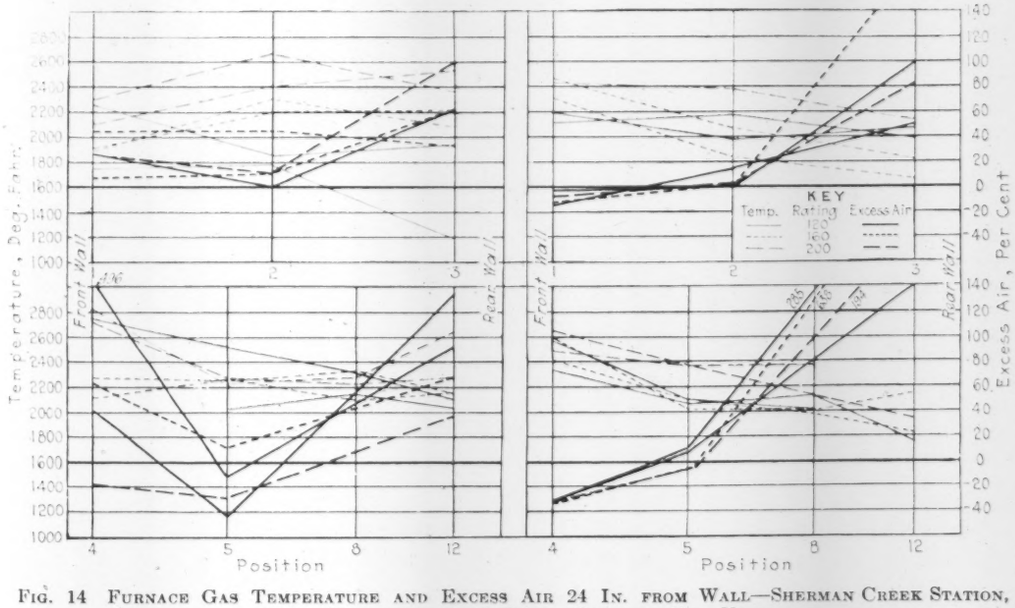


FIG. 14 FURNACE GAS TEMPERATURE AND EXCESS AIR 24 IN. FROM WALL—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

TABLE 4 SOFTENING TEMPERATURES AND COMPOSITION OF SLAG FROM WALLS OF UNDERFEED-STOKER-FIRED BOILER—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER CO.

				Composition, per cent (moisture and combustible-free)[1]									Deg. fahr.				
Equipment	Location of sample	Remarks	Sample No.	Silica	Alumina	Ferric oxide	Ferrous oxide	Calcium oxide	Magnesium oxide	Total iron as Fe_2O_3	Fe_2O_3-FeO ratio	Silica-alumina ratio	Deformation temp.	Softening interval	Softening temp.	Flowing interval	Fluid temp.
Solid brick walls	Front wall		50	48.8	27.7	12.0[2]	...	5.6	2.1	12.0	....	1.76	2140	60	2200	90	2290
	Front of side wall		51	47.4	29.2	7.3	4.9	5.2	2.4	12.7	1.35	1.62	2150	50	2200	120	2320
	Middle side wall		52	54.7	29.1	2.0	6.6	3.2	1.7	9.3	0.27	1.88	2080	200	2280	230	2510
	Bridgewall		53	48.8	29.6	9.3	3.0	5.0	2.1	12.6	3.55	1.65	2110	70	2180	80	2260
	Bridgewall	Unfused ash	54	49.6	29.1	6.7	4.7	4.3	2.1	11.9	1.29	1.79	2090	90	2180	80	2260
	Bridgewall	Fused slag	55	52.2	28.6	7.1	2.8	4.0	2.0	10.2	2.30	1.82	2090	110	2200	160	2360
High side-wall tuyeres	Side wall	Unfused ash	56	54.4	28.2	9.5[2]	...	3.5	1.7	9.5	....	1.93	2130	120	2250	130	2380
	Side wall	Fused slag	58	55.1	28.0	3.8	5.7	2.9	1.6	10.1	0.60	1.97	2080	110	2190	270	2460
	Front wall	Over tuyeres	57	52.1	28.6	2.2	7.5	4.0	1.9	10.5	0.26	1.82	2080	70	2150	200	2350
	Front wall	Over retorts	59	51.6	29.3	2.9	7.5	3.3	1.5	11.2	0.35	1.76	2080	70	2150	70	2220
Ventilated blocks and low side-wall tuyeres	Front wall	Above tuyeres	67	51.2	29.8	6.5	4.5	3.2	1.4	11.5	1.30	1.72	2110	130	2240	170	2410
	Front wall	Above retorts	66	51.2	29.9	7.4	3.3	3.0	1.5	11.1	2.00	1.71	2080	110	2190	200	2390
	Side wall		68	54.0	29.3	7.1	2.1	2.9	1.4	9.4	3.10	1.84	2110	150	2260	150	2410

[1] Samples contained some combustible matter, possibly coal left on wall of cold furnace.

[2] Total iron calculated to Fe_2O_3. Could not determine ferrous oxide on account of organic matter present.

The silica and alumina and the silica-alumina ratio do not vary greatly from those of the coal-ash samples. The total iron content is somewhat greater in the slag samples than in the coal ash. The content of calcium and magnesium oxides is also greater in the slag samples. The reason for this increase is not evident for mixture with the refractory would not have tended in this direction.

The items of particular interest are the ferric and ferrous oxide contents and their ratio. The ferric is greater than the ferrous oxide in those samples from the bridgewall and from the front wall with the ventilated blocks where, as it has been shown, the excess air was high. And conversely, the ferrous is greater than the ferric oxide at the middle of the side wall and on the front wall with solid brick walls where there is a deficiency of air.

There is no apparent relation between the ferric-ferrous oxide ratio and the softening temperature. This may be masked by variations in the calcium and magnesium oxides or the alkalis which

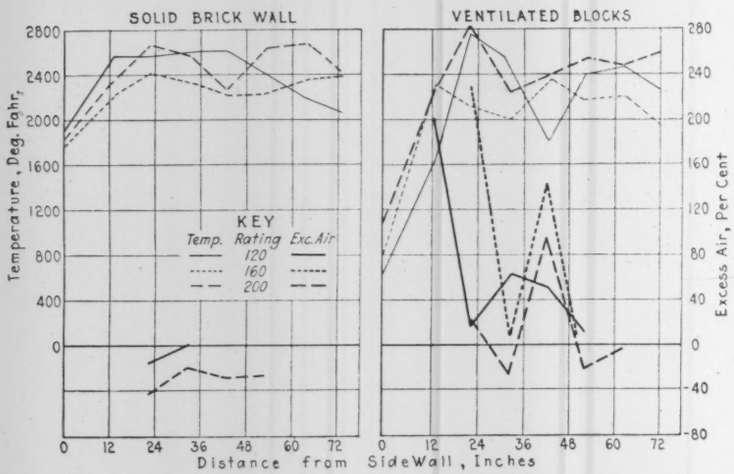


FIG. 15 GAS TEMPERATURE AND EXCESS AIR AT FRONT WALL—SHERMAN CREEK STATION, UNITED ELECTRIC LIGHT & POWER COMPANY, NEW YORK

were not determined. The softening temperatures of the slags range from 2150 to 2280 deg., or from 200 to 300 deg. lower than the softening temperatures of the coal ash.

The fused and unfused samples were taken to determine whether the unfused material was in that state because of a difference in composition or because of a lower temperature in that area. There are no essential differences between the fused and unfused samples. Hence there must have been a difference in temperature in the two areas.

The similarity of the two samples taken over the tuyeres and over the retorts on the front wall checks the gas composition and temperature survey in showing that there is no consistent variation of temperature or excess air corresponding to the peaks and valleys of the fuel bed.

The action of the slag on the refractories is normally too slow to permit drawing any conclusions in regard to the relation of the furnace conditions to the service during such a limited period as that covered by this experimental investigation. The furnace was operated for 13 days with the solid walls and ordinary horizontal tuyeres, a maximum rating of 220 per cent being reached. The walls had eroded in this time to a depth of 1 to 2 in. above the fuel bed at the zone of maximum depth of fuel. This was erosion as distinct from the breaking from slicing the slag from the walls, which had also occurred just below the eroded area.

The period of operation with inclined side-wall tuyeres and solid walls was too limited to draw any comparisons of service.

The furnace was under observation six days with the installation of the ventilated blocks. There was no noticeable erosion at the end of this time, and practically no damage to the blocks from slicing accumulated slag. Although slag did accumulate it appeared not to adhere strongly. It was noted in other furnaces of the station that after a time the air holes in the blocks tended to become plugged with slag and adhesion and some erosion occurred.

Observation of the flames at the side wall with solid brick walls showed that the flames struck the wall above the fuel bed, while with the ventilated blocks they apparently did not. The air probably came through the openings at sufficient velocity to prevent impingement of the flames.

SUMMARY OF RESULTS

1 The temperatures of the surface of the refractories ranged from 2100 to 2500 deg. They were not apparently lower on the surface of the ventilated blocks than of the solid bricks, except when caused by slag accumulation, but the gradient was much steeper and less of the wall was at a high temperature. The lowest temperatures measured were in the bridgewall and the highest on the front wall.

2 The survey of gas temperature and composition showed great stratification in the furnace, with high temperatures and deficiency of air at the front wall and middle of furnace, and low temperatures and high excess of air at the bridgewall. The ventilated blocks furnished sufficient air at the front wall but had little effect in the middle of the furnace, except at the wall surface.

3 The high inclined side-wall tuyeres which had the same area of air openings as the horizontal tuyeres which they replaced did not increase the excess air above the fuel bed but the low inclined tuyeres which had air openings 50 per cent greater in area apparently increased the excess air at the side wall. It is probable that the greatest value of these tuyeres in protecting the wall lies in the fact that they reduce the refractory area exposed to slag action.

4 Neither the side-wall tuyeres nor the ventilated blocks admitted so much air as to materially affect the excess air in the last pass.

5 The composition of the slag samples taken from the furnace walls showed coincidence of high ferrous oxide with zones of high temperature and low excess air. There was no apparent relation between the ferric-ferrous oxide ratio and the softening temperature of the slags.

6 Limited observation of the action of the slag on the walls indicated that the erosion and adhesion were less severe with the ventilated blocks than with the solid walls.

The investigation was carried on under the general direction of C. F. Hirshfeld, Chief of the Research Department, Detroit Edison Company, and under the immediate supervision of P. Nicholls, Fuel Engineer, and G. A. Bole, Supervising Ceramist, Bureau of Mines.

The Charles T. Main 1926 Prize Award Paper[1]

Effect of the Cotton Gin upon the Politics of the United States from 1787 to 1857

By W. CROMWELL SAYLOR,[2] BALTIMORE, MD.

In the preparation of this paper the author had in mind the fact that great and important events often have their origin in seemingly insignificant sources. He shows how the invention of the cotton gin, an event which attracted no more than local interest at the time, revolutionized an industry, molded a social system, and divided a great country into two opposing camps. He shows that it was responsible for the establishment of slavery in the South. The political dispute over this institution was the dominating factor in the history of the United States in what is known as the Middle Period. The Republican Party and the Civil War were results of the hundreds of cotton gins whirring away in southern plantations. In the preparation of the paper the author freely consulted the histories of the United States by Channing, McMaster, and Rhodes. He also resorted to the use of the volumes of "The American Nation. A History," edited by Prof. A. B. Hart of Harvard, a work containing contributions from the pens of many eminent scholars.

THE TERM "politics" has a number of connotations which depend somewhat upon the experience of the individual. For our present purpose we shall consider "politics" as relating more to ideas and concepts on political questions than on the outcome of the hullabaloos and intrigues of office-seeking. From this viewpoint "politics" may be defined as "the expressed opinions of groups of citizens upon the administration of public affairs."

The question suggested by the title, then, is: What was the effect of the invention of the cotton gin upon political ideas in the United States of America during the period 1787–1857?

During this eventful era of our national history there arose some of the most trying and perplexing problems that statesmen have ever faced. It was in the "Middle Period," beginning with 1815 and lasting to the eve of the Civil War, that new issues arose, new forces were set in motion, and new men, with new ideas, clashed. It is this period which furnishes the field of our investigation. The effect of the new cotton culture began to be felt, the South grew rapidly in political importance, manufacturing was established in New England, the western frontier moved nearer and nearer the Pacific, and the prestige of the young nation rose in the eyes of foreign powers. We shall see that the cotton gin had something to do with this growth, particularly with reference to the institution of slavery in the South.

Slavery

Undoubtedly the dominant factor in the history of the nation during the Middle Period was the controversy over the question of slavery. This institution, as it was recognized and defended by so large a part of the country as the South, became "inseparably bound with every important question of internal policy."

Slavery was introduced in the colonies in 1619. The slave trade grew rapidly and the tobacco plantations of Virginia and the adjacent colonies flourished. The planters became gradually convinced that slave labor was necessary and essential for their prosperity. Then in 1776 came the signing of the Declaration of Independence with its high ideals of brotherhood and equality for all mankind. After the Revolution, the sobered thoughts of the victors turned to the improvement of their economic situation.

In the years following there was a growing tide of feeling for the abolition of slavery. All the northern states as far south as Pennsylvania gradually enacted laws forbidding its existence. When the Constitution was drafted in 1787 it was provided that the importation of slaves should cease after 1808, and in the Northwest Ordinance, passed in the same year, the territory north of the Ohio River was forever made free. Even in the South there were many prominent men who felt that slavery was an evil which in time would become obsolete. Why was it then that this institution was not abolished when there was gradually developing such a strong opposition to its existence? The answer lies in the rather commonplace event of the visit of a New England school teacher to the home of his Georgia friends. There he invented a simple machine which caused himself a great deal of trouble, gave the South an era of unprecedented prosperity, and the nation the sorest controversy of its history.

The Cotton Gin and Its Immediate Effect

Eli Whitney was born in Westboro, Massachusetts, December 8, 1765. He studied at Yale, paying his expenses by teaching school and performing mechanical labor. He was graduated in 1792. Three years later he went to Georgia to teach school, and boarded at the home of the widow of General Nathaniel Greene of Revolutionary fame. He displayed his latent ingenuity by inventing several contrivances which greatly aided Mrs. Greene in her household duties. Neighbors visiting the Greenes one day and discussing the cotton situation, remarked that if a machine could be constructed to separate the seed from the fiber, the invention would enrich the South beyond comprehension. Whitney did not know much about the conditions of the cotton industry, so he decided to investigate.

Of all the places in America, the region best fitted for cotton growing was the vast uplands of the lower South. The planters looked with longing eyes upon this virgin soil which would bring them wealth and ease if they could only cultivate it, but cultivation was limited by the lack of sufficient labor in the fields. The negro slaves on the plantations were kept busy tearing the seeds from the cotton fiber. This was a most laborious job, requiring great patience. The best slaves could toil all day and produce at the most only four pounds of cleaned cotton, while the average worker felt proud if he produced one. If the planter was to make any money at all, he must keep his slaves steadily carding what little of the crop he could raise. As a consequence, industry lagged in the South after the Revolution. Many southerners, discouraged by the lack of something to do, began to migrate to busier states in the North. The great need of the planters was an idea which would unlock the potential storehouse of abundance that lay in the uncultivated fields beyond their own.

This was the situation in the South as Eli Whitney saw it. An idea flashed into his fertile brain and he set to work upon a machine which he named the "cotton engine," or "gin," as it was popularly dubbed. His previous training in machine shops stood him in good stead, for he was compelled to make practically all his tools, even to drawing the necessary wire.

The invention was as simple as it was ingenious. A hopper fed the raw cotton upon a row of circular saws which tore the mass into shreds and freed the seeds. Several brushes mounted in front of the saws removed the lint. The machine was operated by the turning of a crank. One slave could tend a "gin" and do the work formerly done by twenty. The problem of the South was solved by the ingenuity of a Yankee school teacher.

Whitney soon found himself in trouble, for he had scarcely begun his preparations for obtaining a patent when the little shop in which he and his partner, Miller, worked was besieged by clamoring, curious planters who craved to use the machine as quickly as possible. So great was their desire to reap the profits they knew would come by its use that they broke into the house one dark night and bore the machine away for careful inspection. Within a surprisingly short time a dozen gins like Whitney's were in steady service in all the surrounding fields. A long patent suit followed, but by the time it was decided that Whitney had the rights to his invention he was making a fortune from the manufacture of firearms. Had he depended upon royalties from the use of his cotton gin, he would have starved to death.

[1] Abridged. [2] The Johns Hopkins University.

The effects of the cotton gin were far-reaching. It not only built fortunes, but character as well. Its immediate effect was to release scores of slaves on every plantation for labor in the cotton fields. More land could be purchased and cultivated with this added man-power. More bales of cotton would sail across the seas and more coins would jingle in the pockets of happy southerners. The demand for slaves increased with the demand for more land, and any lingering sentiments in favor of emancipating the slaves vanished from the southern mind.

But more important than the economic aspects of the effect of the cotton gin were the social and political ideas born in the souls and minds of the planters. These viewpoints had a profound effect on American politics and history.

When the southern cotton grower surveyed his broad plantation, gave his crisp orders to his overseers or his slaves, beheld his comfortable mansion, his contented family, and conversed with his neighbors upon such weighty matters as the size of the crop or the coming election, he must have felt that he was as a feudal lord on his estate. Indeed, it does not seem strange that his environment should suggest to him in a subconscious manner that, because of his power over scores of human beings and because of the increasing importance of his product, he was superior in position, character, and culture to those outside his peculiar social system. In fact, history records that the planters gradually came to the point where they believed themselves to be the holders of the traditions of English "Cavaliers." Many could trace their line to English families and perhaps visualized their ancestors as barons, knights, earls, or even dukes. Thus there arose in the Southland an aristocracy, overwhelmed in numbers by the democratic North, but excelling in political ability and social pride.

The members of this aristocracy were molded for leadership from their birth. They were, by necessity, masterful; some cruel and vicious, many more the kindest of men. They were courteous and "cultured" to such a degree that "southern hospitality" is a tradition in our country today. They were very touchy in regard to their "honor," and the duel was a favorite means of settling minor disputes and insults. Their chief interests were their crops, slaves, family life, neighborhood affairs, and politics. The rearing of such an aristocracy founded on such a system of enslaved human beings was the outgrowth of the rapid spread of cotton culture made possible by the invention of the cotton gin.

Growth of the Cotton Industry

The growth of the cotton industry may be seen in the following figures:

Cotton Crops, 1791–1834

	Million Lb.[2]
1791	2.0
1801	40.0
1811	80.0
1821	177.0
1826	330.5
1834	457.5

The sudden increase in production after 1795, the year of the first cotton gin, is well shown. The crop practically doubled every ten years. The demand for cotton is indicated by the following quotation from Channing:

> Few things in this world have so greatly influenced modern life as the fiber of the upland cotton plant. The development of the demand for cotton goods throughout the world is one of the extraordinary phenomena of the nineteenth century. People left off wearing garments that had been handed down by elder brothers and sisters, and from fathers and mothers, and clad themselves in clothing made of cheap and enduring cotton fiber instead of the more expensive and longer wearing flax and wool. Families laid aside their linen sheets for those of cotton, and the sailing ships of the world—with the exception of men-of-war—ceased the use of linen duck in favor of cotton sail cloth. And whole races of mankind and womankind, who before had been innocent of clothing, now attired themselves in yard after yard of cotton cloth.[3]

In 1812 the youthful nation of America took up arms against the British. When the wounds of battle had healed there still lingered in the national life the sources of further trouble, unfortunate but unavoidable.

[2] The American Nation. A History, vol. 14, p. 47.

[3] Channing, History of the United States, vol. 5, p. 407.

While the American navy was battering the English at sea the people of New England, in normal times the receivers of foreign commerce, because of the blockade found it necessary to turn to manufacturing for themselves. There thus sprang up in the North factories and mills to supply the needs of the nation and make it virtually independent of foreign trade. Cotton mills developed, due to the invention of the power loom by Crompton and Arkwright, and absorbed a large portion of the cotton of the South, creating a demand for a larger cotton production. These northern manufacturers later caused the South a great deal of irritation.

The First Tariff

As soon as friendly relations had been resumed with Great Britain the ships of its commercial navy poured upon the wharves of New England a mass of all sorts of manufactured articles and cheap cotton goods at prices far lower than American manufacturers could possibly offer without ultimate ruin. The English realized that the rising American manufacturers were a serious menace to their world-wide trade, and resolved to do everything possible to suppress these "infant industries." The native industrialists fought earnestly to retain their customers, and at last in despair appealed to Congress for aid. In 1816 Congress enacted a protective tariff covering staples, designed to discourage the "dumping" of cheap goods upon American markets. The South joined with the North in supporting the tariff, partly because it thought that manufacturing would be established in the South, and partly because it expected to derive some benefit from it due to increased home consumption of cotton.

In eight years this friendly coöperation of the South gradually changed to firm opposition to protective tariffs in general. A period of general depression set in about 1815 and continued into the early twenties. Weather conditions were adverse, crops were poor, buying was slow and limited. The South realized that it was not reaping the benefits it had expected from the tariff. The tariff, of course, was not the source of the "hard times," but it was a convenient place to lay the blame for unprosperity. The planters had a reasonable cause for complaint, however, in that the tariff forced them to pay high duties on cotton cloth and hemp, and thus raised the cost of clothing the slaves and bagging the cotton for shipment.

There was a political reason for dissent as well as an economic one. The fierce debate in 1820 on the question of whether Missouri should be admitted as a slave or as a free state caused the nation to realize that there was a distinct division in the Union on political ideas. Thousands had poured into the West over the great National Road after 1815 and the government of the new states that were rapidly being formed became an important problem. After much heated discussion the question of slavery beyond the Mississippi was settled by the Missouri Compromise in 1820, and Missouri was admitted into the Union as a slave state. At the same time Maine was admitted as a free state. All the remainder of the territory in the Louisiana region, purchased from France in 1803, west of the Mississippi River and north of 36 deg. 30 min. latitude, was to be forever free. This struggle of ideas and wills revealed that in Congress the North controlled the House, but that the South mastered the Senate. Thoughtful men on both sides foresaw that this incident was but the beginning of further divergence of political ideas centering around the institution of slavery. The forces underlying this political struggle will be indicated when the annexation of Texas and the Kansas-Nebraska bill are discussed.

Attempts to Abolish and Evade Tariff

The spirit of independence and sectional pride was aroused in the South. When the northern manufacturers asked for more protection in 1824 the South opposed it, but they were overruled. The higher duties on imports imposed by the new tariff did not seem to help the manufacturers, and again they appealed for aid in 1827. As it seemed that the principle of protection was firmly rooted in the New England states, the only course for the South to take was to attack the constitutionality of the tariffs.

Nothing is directly said in the Constitution about levying a tariff of this kind, but those defending it turned to the phrase which gives Congress the power to "lay and collect taxes, duties, imports and excises, to pay the debts and provide for the common defense and

general welfare of the United States." The argument based on the northern interpretation of this clause was denied by the South with the claim that it was mere favoritism which taxed an agricultural section to benefit the manufacturing states.

It was the old question of whether the Constitution should be construed "strictly" or "loosely." The "strict constructionists" held that Congress could do nothing unless the Constitution expressly sanctioned it. The "loose constructionists" were convinced that the Constitution was elastic enough to cover all cases not explicitly mentioned. The debate was not merely an academic parade of fine phrases and hair-splitting distinctions; both sides, especially the South, where politics were discussed as a popular pastime, were decidedly serious in threshing out a question which involved the foundations of the Union itself.

In 1827 three contestants were striving for the Presidency; Adams of New England, Clay of Kentucky, and Jackson of Tennessee. All three candidates were in favor of protection in an effort to win the large votes of the North, but the friends of Andrew Jackson in Congress wished to appeal to the South also. They introduced a bill which placed a high tariff on such articles as iron, hemp, and wool, with the idea that the New England states would protest against it, join with the South and defeat the tariff bill. Then it was thought that Adams and Clay would be rejected, Jackson would be elected, and upon assuming office could handle the matter of tariffs as he saw fit. However, things did not work out exactly as planned. Many New England manufacturers did protest against the tariff, but so strong was the sentiment for protection in the North that the "Abominable Tariff" Bill became a law in 1828. In the national election of that year Jackson was elevated to the Presidency with the solid support of the South as a justification of its ideals.

The cotton states had been defeated on the question of the tariff. The thought next in the minds of its leaders was: Could they justly evade the Government and refuse to pay the tariff duties which were the source of a great loss? The leaders of southern opinion so thought. Calhoun's "Exposition," presented at a protestation session of the legislature of South Carolina, and setting forth the wrongs done to the South by the North, presented a partial solution. It suggested that the states were sovereign and could exercise their sovereign rights by refusing to recognize any federal law not acceptable to their wishes. This was the beginning of the doctrine of nullification. According to this theory the disagreeing state would not go into revolt or withdraw from the Union, but would simply nullify and declare void any statutes of the central government opposed to its views. All that the central government would do in reply would be to politely acquiesce. Other states in the South joined South Carolina in protesting against the tariff by adopting the nullification idea.

In 1829 and 1830 the whole question of the interpretation of the Constitution in reference to nullification was the subject of one of the greatest debates in Congress. Senator Hayne, of South Carolina, contended that the power of the Federal Government should be restricted, that the individual states were the partners to a compact, and that these partners could nullify the statutes unfavorable to them as set forth in Calhoun's "Exposition." Daniel Webster, senator from Massachusetts, proceeded to brand such an attitude as nothing short of rebellion, contending that the only way for the states to get rid of an unfavorable law was to repeal it, or amend the Constitution.

The nullifiers were quiet until 1832, when another tariff bill was introduced for discussion in Congress. This was the signal for a renewal of the fight. The bill was modified by compromise, but not until the disunion sentiment became so strong in South Carolina that President Jackson in a proclamation warned the South that the integrity of the Union must be preserved—with force, if necessary. This firm declaration and the passage of the "Force Bill," which provided for the collection of tariff duties by armed force, where necessary, had the effect of outwardly suppressing the rebellious spirit in the South. The idea of nullification died away, but the fires it had lighted smoldered on only to break forth elsewhere with greater violence.

The source of the nullification idea lay back in the days when cotton was cultivated only on the lowlands of the coasts. In the second half of the eighteenth century a flood of immigration swept through the Shenandoah valley. Soon the planters came to realize that these settlers, who devoted their energies mostly to corn and wheat, were menacing the political control of the cotton states, as they were decidedly in the majority. The cotton growers feared that if the farmers gained control of the legislatures, they would tax slaves in order to obtain funds for internal improvements, such as roads and waterways. The planters found it necessary then to resort to some scheme whereby the minority could control the majority. They refused to allow a reapportionment of the representation in the legislatures on the basis of numbers. This was in the days when the cotton industry was small and the planters had to guard jealously what power they had. The invention of the cotton gin enormously increased the political power of the planters. When the cultivation of cotton spread to the uplands the growers felt safe in permitting the farmers a better representation. In fact, the white wave of cotton slowly moving westward banished many of these farmers from the interior.

When in about fifty years the South felt that the Federal Government was encroaching upon the rights of the states, it again considered it necessary that the minority arm itself against the control of the majority. The doctrine of nullification showed how far the South was willing to go in defense of its convictions, even though disunion seemed the inevitable result, and further revealed that the breach between northern industry and southern agriculture was widening to the point of complete unreconciliation.

The Abolitionist Movement

No sooner had the concept of nullification succumbed when fresh winds arose to fan the flames of disagreement. In 1830 the Abolitionist movement had its beginning in New England under the leadership of William Lloyd Garrison. The North was about equally divided in its support of this campaign for the national abolition of slavery. Year by year the movement gained momentum, protests became more persistent, and the South became more indignant at the relentless attacks upon its social system.

New States

While cotton bales were being shipped across the seas, while the looms of New England were humming busily, while political ideas were the topics of the hour, there was a growing flow of immigration to the unsettled country of the Louisiana Purchase. This great area lay between the Mississippi and the Rockies from the Gulf of Mexico to the present northern boundary of the nation. Thousands of families forsook the comparatively peaceful life of the East for the hardships of the West.

The pioneers pressed on into those territories to the West and Southwest belonging to Mexico. From 1816 to 1840, eight new states were admitted to the Union, five of them entering by 1820. The controversy over Missouri has already been briefly mentioned. It was a foreshadowing of what was to come with the acquisition of more territories. The Missouri Compromise was soon seen to be no settlement of the differences between the slaveholding South and the "free-soil" North.

Numbers of settlers, mostly from the region of the cotton states migrated into Texas, then belonging to Mexico. Several attempts were made by the United States Government to annex Texas by purchase, but they were unsuccessful. Disputes between the Texans and the Mexican Government in 1835 resulted in a revolution which forced out the Mexican officials and established a provisional government. Texas then sought to be annexed to the Union.

However, there was strong opposition in the North to this plan. The admission of states had been so maneuvered that there was always an equal number of slave and free states in the Union. The admission of a state above the line marked out by the Northwest Ordinance (1787), and extended by the Missouri Compromise (1820), was balanced by the entrance of a state south of this line. Thus the North and the South were equally represented in the Senate, whose members are limited to two from each state, while in the House of Representatives the North had the majority, as its members are chosen according to the extent of the population. Both sides were desirous of obtaining complete control of the Senate. This was the reason for the bitter dispute over the admission of Missouri in 1820. At that time there were equal numbers of slave and free states—eleven each.

But the South could only hope to carve a few states out of the remaining territory of the Louisiana Purchase below the 36-deg. 30-min. line, while the North had the advantage of the extensive territory to the Northwest, for the Louisiana territory was narrow in the South but widened considerably as it approached the northern boundary of the nation. The southerners were therefore anxious to get the huge region of Texas into the Union. The North was as strongly opposed to any increase in the number of slaveholding states. The annexation question was the issue of the presidential campaign of 1845. Polk, the Democratic candidate, won against Clay, the Whig nominee. Polk was for annexation. Clay equivocated, trying to please both sides. Apparently the people of the United States wanted new territory, whatever the political consequences might be, so Texas was annexed to the United States by a joint resolution of Congress in 1845. This was the beginning of the trouble with Mexico. A series of disputes between the two countries precipitated a deplorable war in 1846, which was ended in 1848 by a treaty of peace. Mexico ceded to the United States for fifteen million dollars all of the remaining territory in western America belonging to it above the present boundary between the two countries. This new region was divided roughly into two sections, California and New Mexico, then much larger than the present states bearing those names.

In 1846 President Polk had desired to purchase this territory from Mexico. When the appropriation bill was brought up in Congress an amendment, known as the Wilmot Proviso, was offered. This amendment provided that these territories could only be acquired from Mexico under the condition that slavery should be forever excluded from the region. The bill and the proviso failed, because Congress adjourned before a vote could be taken.

From 1846 to 1849 the Wilmot Proviso was repeatedly introduced into Congress under various disguises. Every time it immediately passed the House, but failed in the Senate. The Senate was willing to approve a southern proposal to extend the Missouri Compromise line of 36 deg. 30 min. latitude to the Pacific Ocean. The House firmly refused to adopt it. This was very evident proof of the intense sectional difference between the North and the South.

As year after year passed by and the status of slavery in the territories was no nearer settlement, political leaders determined to make a final effort to bridge the gulf between the North and the South. The discovery of gold in California in 1849 brought thousands from all over the world to the Pacific Coast. It was necessary that these men have some form of government. This event and the growing complexity of the slavery problems decided the leaders to put their heads together and get something done. The great question was whether or not slavery should be permitted in the new territory. Every proposed solution brought forth a storm of debate in Congress. Both sides fought stubbornly for their principles. Finally, in January, 1850, the veteran politician Clay introduced his Compromise Bill. More debate, rivaling the fight over the tariff of 1828, followed, but in August, 1850, it was accepted by Congress and became a law. The bill provided that California should be admitted as a free state, and the territories of Utah and New Mexico were to be formed from what was left of the land ceded by Mexico without reference to slavery, that question to be settled when these territories applied for admission into the Union as states. The Compromise of 1850 saved the Union for a few more years. There was widespread hope that the slavery issue would be buried for a long time, as there was very little likelihood that it would be introduced into the arid wastes of Utah and New Mexico. But the southern politicians had great difficulty in explaining to their constituents that all was well with southern aspirations for power.

These historical incidents have been briefly related in order that some conception of the political situation might be formed. The institution of slavery was firmly established in the South by the cotton gin. The loyalty of the South to slavery was the cause of the sectional bitterness we have noted above. The minority of the cotton states were fighting from 1815 to 1850 to gain control over the majority of the North, even as the seaboard planters fought to rule over the inland farmers from 1750 to 1810.

Political-Party Activities

The two political parties during this period were the Democrats and the Whigs. The Democratic Party came into being with the election of Andrew Jackson in 1829. It believed in states' rights and the restriction of the power of the Federal Government. The Whigs were the political descendants of the Federalists, the party of the post-Revolution period. They had more liberal views of government than the Democrats. In fact, it is hard to say just what were the exact principles of both parties. They were interested solely in winning elections. Their adherents were scattered all over the country, in the North, South, and West. It was thus necessary for them to be very careful as to which side they took on the main political issues of the day, slavery and the tariff. They were so very careful, in fact, that they failed to mention these issues in their campaigns in an effort to retain as many votes as possible. The discussion of the slavery and tariff questions did not have any effect upon party platforms except to make them "pussyfoot." When the Democrats or Whig men won their elections and got to Congress or the White House they were unhampered by campaign commitments. The intense sectional rivalry was based on the individual's point of view and not on party adherence. Sectional loyalty excelled party loyalty. Political ideas had more force than political parties. This was the situation in party politics up to about 1852.

A few more of the important events in American history in relation to our subject will be mentioned in closing this survey of the Middle Period (1815–1857). The parties were anxious to maintain as long as possible the calm that followed the Compromise of 1850. In 1854 the storm broke again, due to a political blunder of Stephen Douglas, of Illinois, the future opponent of Abraham Lincoln. Congress was considering a form of organization for the middle section of the Louisiana Purchase to the west of Iowa and Missouri, known as Nebraska. Douglas vaguely proposed that at the proper time this territory should be admitted as a state "with or without slavery." He was immediately challenged to declare exactly what he meant. Senator Dixon, of Kentucky, introduced a bill repealing the Missouri Compromise. In a panic Douglas lined up behind this proposition. The North became alarmed and the South stood ready to seize any chance for more power. The Nebraska territory lay to the north of the parallel of 36 deg. 30 min. therefore slavery in it was banned by the Missouri Compromise Bill of 1820. Just to the east of it was the slave state of Missouri, rapidly filling with pioneers who wished to press on into Nebraska. The South saw an opportunity to get additional slave states, if the Missouri Compromise would be repealed. The North was determined that this should not happen. Douglas soon introduced another bill which proposed to divide the territory into two parts, Kansas and Nebraska, and to repeal the Missouri Compromise. Another fierce debate opened in Congress and lasted continuously for three months, with the most undignified proceedings in the House of Representatives. Finally, on May 30, 1854, the bill became a law and the Missouri Compromise was repealed. This was the deciding turn in the road "which led straight to the Civil War." The nation was thrown into a turmoil. Political parties crumbled into a chaos of many minor fighting groups. Bloodshed in Kansas in 1856 between the rival groups of slaveholders and "free-soilers," who set up separate governments, accelerated the flood of angry passion. The Federal Government adopted a policy of "hands off," but the incident was the cause of bitter speeches in Congress.

Many minor political parties were born in this time of confusion, the most important and enduring being the Republican. It was organized in Michigan in 1856 and took an unqualified stand against slavery and "the revolting aristocracy of the South." It had varying success, but in 1858 it was the strongest party in the nation.

Such was the trend of political events in the Middle Period of the history of the United States. Is it too much to say that the invention of the cotton gin in 1795 affected the political ideas, the politics, of the United States during those years?

Summary

The cotton gin released hundreds of slaves from the arduous task of picking the seed from the fiber for labor in the fields. This made possible the rapid expansion of cotton growing and increased the value of slaves. Slavery became an institution as firmly rooted as cotton plants in the South. Plantation life produced an aristocracy of "southern gentlemen," strong, courteous, fiery, impetuous, masterful, who early learned the necessity of defending the minority

from the dominance of the majority. The tide of immigration into the West after 1815 carried the cotton industry to the Mississippi. Southern settlers pressed into the new territory beyond the great river, taking their slaves with them. Here northerners and southerners mingled in mutual misunderstanding.

The only products of the South were raw cotton and polished gentlemen. The section was dependent upon imports for necessities. When the manufacturers of the North and the pioneers in the West incessantly appealed to Congress for a protective tariff and internal improvements, the South felt that the grant of these pleas would tax the planters for the benefit of other sections. The doctrine of nullification arising in South Carolina was simply a scheme for the defense of the institution of slavery and the dominance of the power of cotton. The events that followed after 1828 were but the development and enlargement of this plan to overcome the opposition of northerners. Each side thoroughly misunderstood the other. The northerners after reading "Uncle Tom's Cabin" thought of the southerners as heartless bullies. The southerners in turn considered their opponents as cowardly" infidels" because they refused to engage in duels and had new ideas on age-old topics, for the rapidly rising industrial and intellectual life in the North made virtually no impression on the South. The cotton growers were not ignorant numbskulls, but they refused to be moved by the flood of new ideas which swept the North.

The South had an increasing realization of its political importance. The slogan "Cotton is King" was their watchword in the years before the Civil War. The following quotation from a southern writer illustrates the attitude of the section. "In the three million bags of cotton the slaveholder annually throws upon the world for the poor and naked, we are doing more to advance civilization. . . . than all the canting philanthropists of New and Old England will do in centuries. Slavery is the backbone of the northern commercial as it is of the British manufacturing system. . . .Our labor has enabled us to make New England rich." This attitude was a direct result of the invention of the cotton gin, which made the great cotton industry possible.

We can also say that the rise of the Republican Party can be traced to the cotton gin, for it was the nucleus of the antislavery sentiment which crystallized in 1854. The minor groups antagonistic to southern interests lined up behind its banner. The campaign of 1860, culminating in the election of the Republican candidate, Abraham Lincoln, was the final step in the great controversy. The southern states seceded from the Union. The attack on the Stars and Stripes floating over Fort Sumter in Charleston harbor was the signal for the outbreak of the Civil War in 1861.

1926 A.S.M.E. Student Prize Award Paper

Pressure Distribution over a U.S.A.-27 Aerofoil with Square Wing Tips—Model Tests[1]

BY CECIL G. HEARD,[2] TORONTO, CANADA.

The investigation described in this paper was undertaken to determine the distribution of loading over a U.S.A.-27 aerofoil with square wing tips, the tests being conducted in a wind tunnel. A brass plane of 3 in. chord and 18 in. span constructed for pressure plotting was used, and by employing a duralumin dummy identical in form and section, the pressures were measured over the brass plane as a monoplane and as the upper and lower wings of three biplane combinations of varying degrees of stagger. The effect of stagger on the distribution of the loading is considerable—as the stagger is increased the load on the upper wing increases while that on the lower wing decreases, the ratio of the load on the upper wing to that on the lower varying from 1.02 with no stagger to 1.52 with 30 deg. stagger at 0 deg. incidence.

ONE OF THE objects of an airplane designer is to reduce the deadweight of the machine to a minimum, as every decrease in deadweight means a corresponding increase in the useful load which may be carried. For rational design the manner in which the load is distributed over the parts must be known.

The two methods of obtaining information are:

1 Tests on full-scale machines in flight
2 Tests on models in a wind channel.

The second method is now extensively used. It allows data to be collected in less time and at a lower cost than by means of tests on full-size machines. If the designer has reliable data of the performance of machines of a similar nature to the one he is designing, both model tests and full-scale tests, the results of model tests can be corrected to apply to a full-scale machine, with considerable accuracy.

DESCRIPTION OF APPARATUS

This investigation was undertaken to determine the distribution of loading over a U.S.A.-27 aerofoil with square wing tips, the tests being conducted in the 4-ft. wind channel at the University of Toronto.

This channel, of the Royal Aircraft Establishment type, has a working section 4 ft. square and 24 ft. long, the models being supported in the central part of this section. The air is drawn past the models by a four-bladed propeller, 9 ft. 6 in. in diameter driven by a variable-speed d.c. motor. The wind speed in the central 3-ft.-square section of the channel in the region near the models is everywhere within 0.5 per cent of the mean velocity in this section.

The model over which the pressure distributions were measured (Fig. 1) was brass, 3 in. chord by 18 in. span. The section and chord were uniform along the span and the ends were finished off square with the leading edge and the tangent plane of the undersurface.

The tubes into which the pressure openings were drilled were german silver, of 0.6 in. outside diameter and 0.4 in. bore. Eight grooves were milled in the lower surface of the aerofoil parallel to the leading edge and the tubes soldered in place in the bottom of the grooves before the aerofoil was cut to shape. This gave a perfectly smooth under surface without any of the irregularities which would be certain to occur if the tubes were soldered in after the aerofoil was cut to its finished dimensions.

The pressure openings were drilled into the tubes from both surfaces of the aerofoil with a 0.02-in. drill. There were six sections (*A* to *F*) of openings on the semi-span, one section being at mid-span and the one nearest the wing tip being $^1/_4$ in. (0.083 chord) from the end of the aerofoil. The openings were spaced closer together where the pressure gradient is steepest (near the leading edge) and near the wing tip where the distribution of load along the span changes more rapidly than it does along the central portion of the aerofoil.

The dummy plane which was used with the brass pressure plotting plane for biplane combinations was made of duralumin. It was identical in plan form and section to the brass plane, but without tubes and pressure openings.

The multiple slanting manometer (Fig. 2) used contained 10 tubes, which allowed the 8 pressures on one surface of a section to be measured simultaneously. The upper ends of the two outside tubes were connected directly to the top of the reservoir. These two tubes indicate at all times the level of the liquid in the reservoir and the zero readings of the central tubes which are connected to the model.

The manometer was calibrated in inches of water against the modified Chattock gage used for speed regulation, the level for the

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[2] University of Toronto.

1 in 10 slope being adjusted. In this way, as long as the level is adjusted, the factor by which the net reading of the gage must be multiplied to obtain the difference in the pressures at the observation point on the model and the side plate is independent of the exact slope of the tubes and the specific gravity of the liquid used, provided this does not change after the calibration.

METHOD OF TEST

The method followed was to determine the pressure distribution on the upper surface at the median section (all the other openings being sealed) for the monoplane at angles of incidence from −4 deg. to +18 deg. The dummy plane was then set up as the upper plane of a biplane with 0 deg. stagger and the pressure distribution at all the angles again determined (the turntable being turned through the angle of incidence in the same direction as the spindle of the balance, to keep the two planes in the correct relative position to the wind direction). The chuck holding the dummy plane was then moved to the next hole in the turntable, the dummy plane lined up and the distribution of pressure at this row of holes obtained for the lower wing of a biplane with 15 deg. stagger and then to the next hole for 30 deg. stagger. The holes in the turntable not in use were closed with setscrews. When the distribution on the upper surface of the median section for the lower wings was completed the turntable was turned through 180 deg. and the distribution over the median section of the upper surface of the upper wings determined.

When the pressure distributions along this row of holes had been determined for all the angles of incidence for each of the structural arrangements, a narrow strip of thin paper was fastened over them with seccotine. The paper was then removed from another row of holes and the same method followed at the new section. This process was repeated until the whole wing was tested.

The wind speed was kept constant for all the tests at 40 ft. per sec.

RESULTS

The difference in pressure registered on the manometer was the difference between the pressure at the observation point and the pressure at the side plate (to which the reservoir of the manometer was connected for convenience). The difference between the pressure at the side plate and the pressure in the region which was occupied by the model with an air speed of 40 ft. per sec. was determined after the test with the Krell slanting manometer.

The observed pressures in terms of ρV^2 lb. per sq. ft. (V in ft. per sec. $\rho = 0.002373$) are plotted in diagrams given in the complete paper. The pressures measured in this manner are assumed to act normally to the surface of the aerofoil at the observation point. The force normal to the chord at each section was determined by plotting the normal-force diagrams, each diagram being a complete record of the distribution for one angle of incidence.

The distributions of the load for each angle of incidence are plotted in Fig. 3 for each of the structural arrangements investigated.

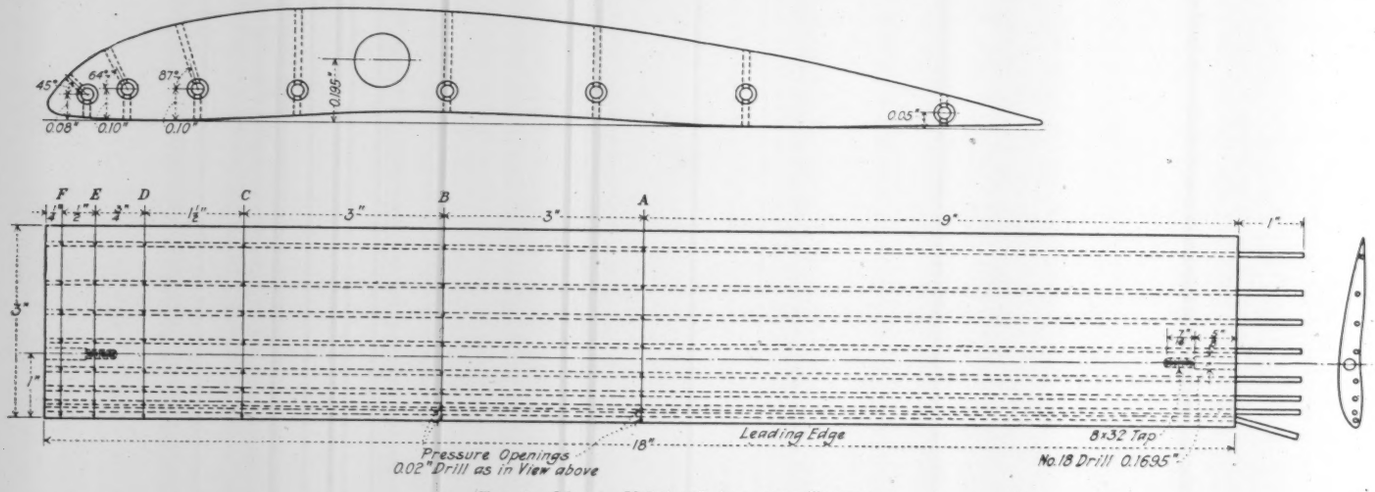

FIG. 1 MODEL U.S.A.-27 AEROFOIL TESTED

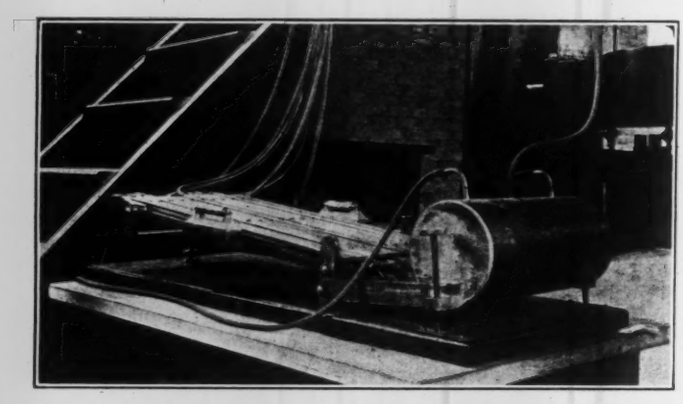

FIG. 2 MULTIPLE SLANTING MANOMETER

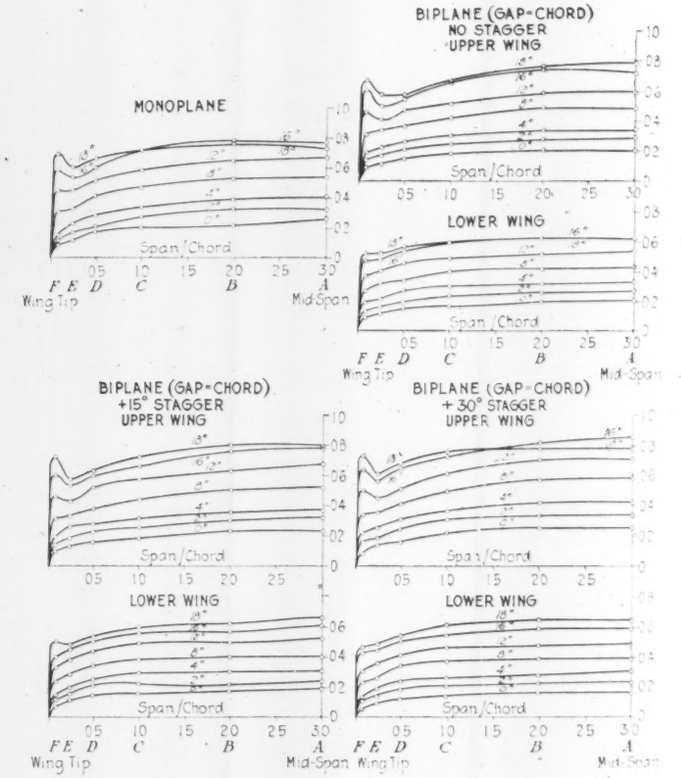

FIG. 3 NORMAL FORCE ALONG SEMI-SPAN

(Wind speed, 40 ft. per sec.; unit of force = ρV^2 lb. per lin. ft. for 1 ft. chord; model 3 in. × 18 in.)

As is generally found with square-tipped aerofoils, an area of high suction at the trailing edge of the wing tip is very apparent at angles of incidence above about 8 deg. for the monoplane and the upper wings of the biplane combinations. On the lower wings the high suction in this area is partially suppressed, the effect of positive stagger of the wings being to reduce this suction still further.

The load along the span decreases from the mid-span to the wing tip for the lower wings at all angles of incidence tested. On the upper wings and on the monoplane the load decreases from mid-span to the wing tip for angles of incidence up to about 8 deg. For higher angles of incidence the load decreases from mid-span to a

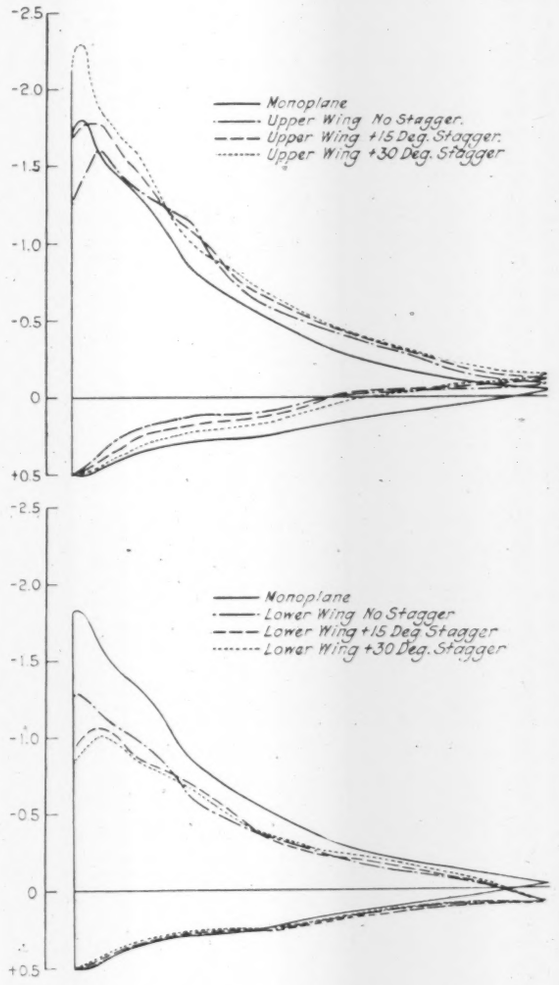

FIG. 4 NORMAL-FORCE DIAGRAMS—MEDIAN SECTION, 16 DEG. ANGLE OF INCIDENCE

section about 0.25 of the chord from the wing tip and then increases suddenly between this section and the wing tip, due to the area of high suction at the trailing edge of the wing tip.

The normal-force coefficients for the complete wings, K_z, are given in a table in the complete paper, where the ratio of the loading on the upper wing to the loading on the lower wing for each angle of incidence of the three biplane combinations is set forth. With no stagger of the wings the proportion of the load carried by the upper wing increases as the angle of incidence is increased, until at 18 deg. the load on the upper wing is 1.18 times the load on the lower wing. At low angles of incidence the loads on the two wings are nearly equal.

With 15 deg. stagger the upper wing takes from 1.16 to 1.23 times the load taken by the lower wings.

With 30 deg. stagger the load on the upper wing varies from 1.52 to 1.23 times the load on the lower wing, the ratio decreasing as the angle of incidence is increased.

To show the effect of biplane construction and stagger on the pressure distribution over the median section at high angles of incidence, the normal-force diagrams for this section at 16 deg. incidence are plotted to a large scale in Fig. 4.

The pressure distributions on the lower surface of the lower wings and on the lower surface of the monoplane are nearly coincident on the combined diagram from the leading edge to close to the trailing edge. The suctions on the upper surfaces of the lower wings are decreased by the presence of the upper wings, particularly in the region of high suction at the leading edge. The effect of stagger on the normal force coefficient of the median section is slight, although the maximum suction at the leading edge is decreased by increasing the positive stagger of the wings.

The effect of the lower wing on the under surface of the upper wing is to reduce the pressures very materially, the pressures on the rear third of the upper wings being negative, whereas the pressure on the under surface of the monoplane is positive along practically the full chord. Positive stagger is advantageous in this respect as the distribution of pressure approaches more nearly that on the under surface of the monoplane as the upper wing is moved ahead of the lower wing. The suctions on the upper surfaces of the upper wings are greater than on the upper surface of the monoplane. The effect of positive stagger is slight except at the leading edge, where the suction increases considerably with positive stagger of the wings.

The increase in the value of the maximum suction near the leading edge of the upper surface of the upper wing as the positive stagger is increased is noticeable at all the angles of incidence tested (except at low angles where the pressure is positive for a short distance from the leading edge), and particularly at the high angles of incidence.

Special Weather Reports for Commercial Airways

IN CARRYING out the provisions of the Air Commerce Act of 1926 the Weather Bureau of the Department of Agriculture since July of this year has inaugurated special service at 17 places selected by the Department of Commerce, the Post Office Department, and the Department of Agriculture as those best located to furnish information concerning weather conditions to fliers along commercial airways. The service includes observations of upper winds by means of small "pilot" balloons, and these observations are as a rule taken a short time before the planes are scheduled to make their flights. The information enables pilots to select the most favorable altitude for flight, or the least unfavorable altitude in case head winds prevail at all levels.

An important feature of the service is the transmission of weather reports from point to point along the airways. The pilot is, if anything, more interested in conditions at places toward which he is about to fly than he is in those at the place from which he starts. Obviously the information, to be of most value, should reach the pilot as short a time before his departure as possible. Thus, if a pilot starts out on a 2-hour flight, and a report tells him as he leaves that the weather at his destination is good and that the outlook for the next two or three hours is favorable, he proceeds with a much greater degree of confidence than if he had no such information. Changes during a flight, even of that short duration, may and do occur, and it is planned ultimately to extend the weather reporting service to include special observations, when advisable, which will be sent to emergency landing fields en route, equipped to set up warning signals, upon seeing which the pilot will either land or turn back. For the present, however, the service will be limited to reports at stated hours, shortly before the departures of planes. It will be organized along all commercial airways where flying is on a regular schedule basis. Instructions to put it into effect along two of the airways have recently been issued. These are the Chicago-St. Louis and the Chicago-Dallas Airways. Along the former, special reports are exchanged between Chicago, Peoria, and St. Louis, and along the latter, between Chicago, Moline, Kansas City, Wichita, Oklahoma City, and Dallas. The reports give upper wind conditions, height of clouds, visibility, the occurrence of fog, rain, thunderstorm or any other unfavorable or threatening condition. As the service develops, it seems likely that, as in other countries, so in this, the weather reports will be a large factor in determining whether or not a scheduled flight shall be made, and, if made, what height will be selected as the safest and most economical.

The Science of Foremanship

Rapid Development of Foremanship into a Science—Primary Essentials of Good Foremanship—Science of Foremanship Inclusive of Science of Management, Supervision, and Teaching—Foremanship the Science of Leadership

By B. H. VAN OOT,[1] RICHMOND, VA.

STANDING between the management and the workers in every industry there is a group of men who are required to view the work of the industry from two different angles. If they are to execute their responsibilities efficiently, they must interpret the work of their respective departments in terms of the problems confronted by both the management on the one hand and the workers whose activities they direct on the other. The personnel of this group of men is usually recruited from among the ranks of the workers. Because of excellency of workmanship, dignity of personality, faithfulness of service, or by virtue of other qualities of leadership, family relationship, or favoritism, these men are given the responsibilities of foremen.

The new positions in which these men find themselves demand abilities entirely different from those required by their former positions. Formerly the men performed work jobs, and with the successful performance of these jobs their responsibilities ceased. In the position of foreman these men do not have to perform work jobs, but are required to see that work jobs are properly performed by others.

In accordance with standards of quality and quantity commensurate with established standards, in accordance with the demands occasioned by economic, social, and market conditions, and in accordance with the best interests and abilities of those who are doing the work, the new positions thus occasion the exercise of different kinds of mental function, embracing among other things supervision, management, and the giving of instruction, or teaching.

It is unreasonable to expect a man who has been promoted from worker to foreman to exercise, or even to possess, all the abilities necessary for successful foremanship. His new job requires a practical application of the principles of industrial management, economics, sociology, psychology, and pedagogy. He now is required to lead, where formerly he followed; he now must give instructions, where formerly he received them; he now must plan operations, estimate costs, calculate wastes, where formerly his mind was engaged along other lines; he now has to coöperate in a managerial capacity, where formerly he did only that which he was told to do; he now has to view his workers with a human-interest attitude, realizing that the comfort, happiness, and success of his workers depend largely upon the manner in which his responsibilities are discharged, where formerly his interests were largely confined to his home and to his most intimate associates. His position in the industry is now reversed; he is a leader, a manager, a supervisor, a teacher, a student of human relationship, an organizer, a planner—an outstanding individual in his department and his community.

Of course it is possible that perfection in foremanship ability may be acquired through the unscientific, haphazard, unorganized, and wasteful method of trial and error. Until recently this was the method pursued by most industrial managers. However, with an added knowledge of the importance of the foreman to the industry, with the realization of the necessity of a coöperative personnel, with an added understanding of the problems of industrial competition, and with an added knowledge of the necessity for the separation and delegation of responsibilities to competent persons, managers are looking upon the position of foreman in a different light and are setting up programs to train their foremen on the job, realizing that it is just as important to teach a foreman on a high level of activity the intricacies of his position as it is to train green hands in the mill on the lower levels of performance.

Foremanship Rapidly Developing into a Science

Foremanship is rapidly developing into a science. The "handle-them-rough" type of foreman is giving way to the scientifically trained minor executive, and the time is not far distant when the industrial executive will pay as much attention to the selection of his foremen as does the commercial house to the selection of their salesmen. There was a time when the commercial house put "on the road" any person who "looked good" to the owner of the house. The chief virtues of these "drummers" were to sell goods, tell questionable stories, and pass out drinks and cheap cigars. The ultimate results of such "drumming" were seldom if every considered. The practice now, as we all know, is to select highly trained gentlemen whose character is beyond reproach and who have at heart the best interests not only of their employers but of their customers as well. Salesmanship has been elevated to a respectable position, comparable to that of almost any profession. Questionable methods have given way to scientific presentation based upon economic and social laws, and rowdyism to gentlemanly conduct; the salesmen have increased business, raised the standard of human business relationship, and to a large extent have been instrumental in bringing about industrial peace and good-will.

So it will be with foremanship when many of the methods now employed by foremen give way to applied psychology, sociology, and the science of management.

Primary Essentials of Good Foremanship

One of the first essentials of good foremanship is a thorough knowledge of the several operations in the department over which he has supervision. This knowledge can be acquired only through experience. It may not be possible for a given foreman to excel in workmanship all workers in his department, but nevertheless it is essential that he know the operations of the machine or process, and know the capacity, the hazards, and the human requirements of production in his department.

This knowledge is but one phase of foremanship. The other phase may be acquired. Many foremen are careful students of human nature and are interested in their positions to such an extent that they voluntarily study managerial and supervisory problems. They take an interest in the welfare of the industry and are successful. It is frequently said of these foremen that they are "natural-born" leaders. The truth of the matter is that they are leaders not because of the nature of their nativity, but because they have capitalized their potentialities and have made themselves successful in their field of activity.

The large majority of foremen, however, while interested in their own and their company's advancement, and perhaps have followed self-improvement devices as far as their own individual capacities would permit, are cognizant of the need for further study and improvement. Realizing this attitude on the part of the foremen, or because of some urgent need in the industry to bring about coordination of functions, many industrial managers, through their own efforts or through the coöperation of some outside agency, are setting up situations wherein the participating foremen have opportunities for self-improvement. These situations are in the form of correspondence courses, study clubs, extension courses, departmental conferences, etc.

The State Department of Education of the state which the author has the honor of representing is coöperating with the several industries within its borders in endeavoring to bring about a scientific attitude toward foremanship. That the service which is being rendered is being appreciated is manifested by the many requests which are being received for additional service. During thef our years in which foremanship conferences have been held nearly twenty-five hundred foremen and prospective foremen have been

[1] State Supervisor of Trade and Industrial Education for the State of Virginia.

Presented at the Old Dominion Meeting of the A.S.M.E., Richmond, Va., September 27–October 1, 1926.

reached. About forty industries have coöperated in making the work a success. At the present time two men are giving their full time to foremanship training, and each is scheduled many months in advance.

It is an every-day occurrence to read about the conventions held by dentists, doctors, clergymen, hardware dealers, cotton manufacturers, school men, fertilizer men, farmers, grocerymen, and a host of other individuals or organizations having common interests. In these conferences problems pertinent to the special fields are discussed and solved. Advancement in any special field is brought about by coöperation and the sharing of experiences, instead of secrecy and isolation, as was formerly the practice.

The philosophy underlying group discussions and the benefits accruing therefrom may be applied to the foremen in a given industry the same as to other individuals having a common interest. The foremen welcome such discussions and frequently contribute valuable suggestions for plant management. The opportunity to exchange ideas and experiences and to thresh out problems and grievances has a wholesome effect upon the organization. Under skilful leadership, the timid and retiring foremen as well as the talkative and over-officious may be encouraged to pool their interests and experiences for the benefit of the entire group. It has been our experience that a leader who is not officially connected with an industry gets better results from the discussion than one who holds a high executive position in the industry. The managers tell us that the foremen are reticent and unresponsive in the presence of the higher officials. Under the former conditions the foremen feel free to express their ideas, and many do so in no uncertain terms. If the reactions of the conferees are tabulated and a result of their findings are collated into a report, the men have a definite record of the proceedings of the conference, which serves not only as a guide to the men in relation to their future thoughts and acts, but gives the management a clear idea of many of the problems about which the foremen are thinking.

Science of Foremanship Embraces Sciences of Management, Supervision, and Teaching

It has been previously stated that the responsibilities of a foreman fall under three distinct headings: namely, managerial, supervisory, and instructional. It is apparent that a man who is promoted from a worker to the position of a foreman knows little or nothing about managing, supervising or instructing, for each of these three fields is a specialty by itself. The manner in which the newly appointed foreman conducts himself depends of course largely upon his personality plus his experience and the amount of information he has gathered through observing the activities of his predecessor and those occupying similar positions of authority. He may have observed the activities of a manager, but to manage embraces information and skills beyond the scope of his experience; he may have observed skilful supervising, but to supervise efficiently requires a different type of knowledge from that which he possesses; he may be skilful in the performance of any piece of work, but to teach another to do that piece of work requires a knowledge of pedagogy and human behavior with which he is not familiar.

The science of foremanship embraces the science of management. It is therefore paramount that the foreman be made acquainted with such problems as the economics of marketing, the elements entering into cost of production, including insurance, taxes, depreciation, transportation, raw materials, and the many other elements entering into the management of a plant. The foreman may not use this information in direct application to his department, but he will use it in indirect application in the reduction of waste, prevention of labor turnover, elimination of breakage, and in his coöperative responsibilities with the management in making prompt, sufficient, and necessary reports.

The science of foremanship embraces the science of supervision. It is therefore paramount that the foreman be taught how to supervise properly. This includes the proper division of his time to supervisory responsibilities; what to look for while in the fact of supervising; how to conduct himself when things go wrong and when things are satisfactory; the proper treatment of his working personnel, his machines, and his materials in process. Supervision includes the proper selection and planning of workers in order that the potentialities of the workers may be capitalized to the best interests of the company and the workers themselves. Supervision includes the regulation of wages and the effects of outside activities or conditions upon the quality of work of the employee; it includes quality and quantity of production, routing and storing of materials, esprit de corps of the working personnel, the temperature and humidity of the working area; and, finally, it includes the securing of new information as the need arises, the modification of programs, the carrying out of definite itineraries, and research to determine causes and effects and utilization of otherwise lost motion or lost material. There is only one way in which the average foreman may be brought to a high degree of supervisory efficiency, and that is through an intensive course in instruction based upon the practical needs of the particular industry.

The science of foremanship embraces the science of teaching. It is one thing to be able to do a job, but it is an entirely different thing to be able to teach another to do that job. Teaching therefore includes a knowledge of pedagogy and human behavior, a knowledge of habit formation, of psychomotor reactions, of asking questions and treating responses, of giving directions and checking reactions, of telling, showing, demonstrating. The foreman as a teacher is confronted with problems the like of which would cause the average college professor to resign in disgust. The foreman's department is a large laboratory in which he instructs not one large class of individuals possessing equal academic preparation, but a large gang of individuals with varying degrees of intelligence; his instruction is not class or group instruction but individual instruction; he teaches not one topic but thousands; he handles not one problem but a multitude of different problems; he handles not one material but many materials. The green hand must be broken in; the experienced hand must be taught new operations or processes. There is a constant reorganization of factory curricula and subject-matter. We ask the foreman to take charge of this huge factory-school, but offer him little or no assistance. The science of foremanship embraces all the science of pedagogy the schoolmaster needs to know plus management and supervision.

So far we have discussed only the importance of information and skills in relation to the specific production requirements of the foreman's job. There are, however, many other requirements of the job. Situations are constantly arising in an industry which call for the coördination of departmental functions. A foreman may be ever so efficient within his own department, but if he is unwilling or unable to coöperate with other departments; if he allows jealousy or selfishness to interfere with company advancement; if he is unwilling to share those responsibilities which cannot be definitely delegated to any one individual or department; if he is not in sympathy with the company's policies and does not properly interpret the same to his workers, he is not discharging his responsibilities to the best interests of his company, his workers, his community, or to himself. In other words, for the best interests of all concerned the foreman must display certain attitudes toward coöperation, job interest, company and job pride, leadership and plant morale, and the many other elements which are essential for successful operations of an industry, the responsibilities for the exercise of which cannot be definitely delegated.

Foremanship the Science of Leadership

Foremanship is the science of leadership. Unless the foreman has the qualifications to go before his workers and lead, he is unworthy of the name of foreman. To lead does not mean to be "hard boiled" and drive, neither does it mean to "pussyfoot" and coax men into the performance of duties. Workers respect neither coercion nor pleading. They do respect leadership when the same is manifested by abilities, honesty of motive, square dealing, executive ability, initiative, self-control, good judgment, loyalty, firmness, and tact.

The proper idea of leadership was recently expressed by a mine superintendent of southwest Virginia.[2] Although he was deprived of the advantages of early academic education due to his having entered the mines at twelve years of age, yet his thoughts and ideals permeate his whole organization. In speaking to his foremen at an informal gathering he said (in part):

[2] C. W. Rotenberry, Superintendent, Armo Colliery, Wise County, Virginia.

My friends, did you ever think of the power you possess as foremen? The man who is unable to control and direct any one but himself, his individual strength is his alone; if another man can direct the thoughts and energy of two men, his strength is twice that of the man who can direct but his own; the man who can direct the thoughts, the acts, the strength and the attitudes of a hundred men has increased his power a hundredfold.

We as miners and we as foremen have perhaps the greatest opportunity to develop ourselves and to grow into real useful citizens of any men anywhere in any country. We sometimes get an idea into our heads that because we delve down into the bowels of the earth and there in the dust and grime bring forth an every-day common commodity, our calling is rather low. Let us not deceive ourselves, for such an idea is altogether wrong. Our calling, our vocation, my friends, cannot be excelled for usefulness and endeavor by any on the face of the earth. I believe it was President Wilson who said during the time of the World War that the world waits upon the miner, that the wheels of industry move as the miner goes forward, and today we realize and know that the wheels of industry are dependent upon the fuel we bring forth from these hills. And now, my friends, in order that we shall get anywhere in this great work as honorable and useful men, it is necessary for us to improve ourselves, to specialize and endeavor each day of the week, each week of the month, and each month of the year to so specialize and to so intensively use our minds that we may become highly efficient in the great work we are doing.

In the splendid course in foremanship that it has been your pleasure to attend, there have been brought forth many of the necessary attributes, many of the necessary elements of foremanship. One of these elements or attributes that has been taught is coöperation.

How often, my friends, it is that we fail to coöperate with one another; how often it is that foremen become jealous of the men under them, become jealous of the men over them. Jealousy causes distress and disappointment and holds a man down. Coöperation, on the other hand, elevates men higher and higher. I remember of having read sometime in the past the descriptions of men climbing the great Alps in Europe. These mountains are covered with sleet and ice and present almost unsurmountable difficulties, yet men are continually endeavoring to scale their peaks in order to get a view of the gorgeous surroundings, to enjoy for the moment the results of their endeavors. When scaling these mountains the men bind themselves with strong ropes to a leader—one who is more skilful and who possesses more experience than the others. They all move up the mountain side in perfect unison and harmony. When they reach a point beyond which it is impossible for the leader to advance unassisted, those who are following give him a push to a higher position. The leader anchors himself securely and then pulls his men up after him. Each in turn is advanced to a higher position. In this manner they ascend the mountain peaks in unison and all accomplish their objectives.

And so it is, my friends, in this organization. The man who starts to climb in this organization with the intention of keeping others pushed back will soon reach the point where it is impossible for him to climb further. The foreman or leader who attempts to climb with the idea of keeping every man below him pushed down will finally reach the place where it is impossible for him to overcome the difficulty without the aid of his fellow-men, and when he reaches that point and looks down behind him and finds that there is no one to lift him up, due to his having pushed the other men down who were following him, he realizes that he himself must fall.

In this organization, my friends, as foremen and leaders, it is our duty to elevate men to higher positions as we ourselves get stronger. It is our duty to impart our knowledge to the men below us and to let our strength move down to the men below us as we advance. Only in this manner will be built up an organization that will be able to compete with any organization in the country. Should it be that jealousy arises in your heart, you should try to retain it in yourselves. Should you try to hold to yourselves all the strength that you have, your knowledge will perish for the lack of imparting it to others. It is absolutely necessary, my friends, that we share responsibilities, share our knowledge and friendship, and all move forward together.

This man has the true meaning of coöperation. The science of foremanship includes not only the attitude of coöperation as expressed by this coal-mine superintendent, but includes a knowledge of the relationship of the industry to the community. We are living in an age of science and industry. We are surrounded by great industrial plants managed and financed by people living in many states. The workers too frequently entertain an idea that these industries are exploiting the workers as well as the raw materials. In some cases this may be true. In most cases, however, it is not true. It is paramount that the foremen properly interpret to the workers the place the industry holds in the community. Industry cannot be conducted today without the capitalist, but the capitalist in turn pays the taxes which build the roads, educate the children, enforce the laws, and make prosperity bloom in every quarter. A comparison of our civilization and our prosperity today in these southern states with that of thirty years ago before the capitalist began to concentrate in our mining districts, our cotton regions, our iron and steel and lumber centers, before capital began to develop our harbors and harness our rivers, and build our railroads, will show even the most conservative the importance of the large corporations. The foreman is the medium through which to best interpret to the workers the true attitudes of those who would develop the assets of our states.

Lastly, though by no means of least importance, science of foremanship carries responsibilities for the education of the juvenile worker. Every year in our southern states thousands upon thousands of children are leaving the public schools to enter the industries. Whether this exodus from the schools is caused by economic or social conditions does not alter the fact that some one must look after their future welfare. These children are to become the mothers and fathers of the state, and as such, through their right of franchise, they will shape largely the future economic, social, religious, and moral status of the South. They are of legal school age and therefore are legally entitled to an education, though they may not choose to accept that type which is offered in the traditional public schools, however excellent we may think it is. They are energetic, intelligent, capable children, most of them, and their potentialities cry out for practical education. They feel themselves forces in the community, and seek the shops, factories, stores, and mines as the places wherein they can best develop their potentialities. The foreman in the place wherein they are employed can be their best friend. He can point out the agencies of advancement; he can encourage attendance in evening and part-time schools; he can encourage thrift, teach moral habits, encourage habits of punctuality, neatness, and courtesy; he can stimulate initiative, set up situations in his shop or department wherein the juvenile may capitalize his talents; he can coöperate with the home, the social and educational institution, the church. His is a position of leadership. He is a "fore"man in society as well as in industry.

Condensation Products—Casein Solids

AMONG the modern plastic materials, the casein solids are taking an important place. Their production as a commercial plastic material is, other statements notwithstanding, a typical French invention. It is based upon the commercialization of one of the essential raw materials, namely, formaldehyde. Trillat, in 1891, noticed that formaldehyde had the property of hardening albuminous substances, and of rendering the same insoluble. Shortly after the manufacturers of buttons, in France, began to adapt the process to the manufacture of small objects, using a mixture of casein, chalk, with or without alum or borax. However, the products did not meet with very much favor. The property of formaldehyde of hardening gelatin was made use of in 1893, and small translucent gelatin plates were manufactured, and used by dressmakers in the adornment of women's clothes. About the same time the firm of *Maison Hullard* began the production of casein objects at Suresnes, in France.

In 1894 the firm of Schering took out the German Patent 107,637; followed in 1897 by German patent 127,942 of Ernst W. Kirsche and Adolph Spitteler. A little later the Galalith Co. took out patents in Germany, thus making M. Trillat's idea practical.

In 1904 the French firm working the Spitteler patent, at a plant founded by Pellerin and Orosdi, merged with the German concern to form the company now controlling the Galalith product, under the name of Internationale Galalith Gesellschaft Hoff & Cie. A branch plant was started at Levallois-Perret, later moved to Gennevilliers (Seine). At that time this was the only plant producing the product. Almost immediately after the outbreak of the European War, the production of casein solids in Germany sharply diminished, and as the French plant at Gennevilliers was placed under sequestration, the French undertook to develop the industry on their efforts.

It is interesting to point out, that while the war was still raging in 1917, France exported 350 tons of hardened casein solids.

The tendency has grown of late to use the names "Galalith" or "gala" for short as a sort of type name for all these products. This is to be deplored and was condemned by the French Syndicate of Casein Solids Manufacturers. It was finally decided to call the material by the name "Caseine durcie," which means hardened casein. The modern American term favors the words "casein solids." The older name, "artificial horn," is not sufficiently precise to meet the requirements. *Plastics*, November, 1926, pp. 395–396.

Progress and Prospects in Mechanical Engineering

FOREWORD

A Review of Recent Accomplishment in Its Various Branches, Prepared by the Professional Divisions of the American Society of Mechanical Engineers

IN THE following pages appear the reports of the various Professional Divisions of the Society, reviewing in condensed form the progress in their respective fields during the past year. All of these reports are interesting, and each gives the latest word in the advance of science and art in its particular field.

No great advances in human knowledge spring fully developed out of the ignorance of the past. They are the result of patiently adding one forward step today to yesterday's most advanced position; and although at some turn of the road a much clearer conception may be had of the location of the goal, its eventual attainment is as much due to the gropings of all of the previous yesterdays as to the more brilliant discoveries of today.

To our members whose work on these Professional Divisions is gradually extending our scientific frontier, are due not only the thanks and appreciation of our own Society, but also of the whole engineering fraternity and of mankind as well.

WM. L. ABBOTT,
President of the Society

Progress in Management Engineering

Contributed by the Management Division

Executive Committee: C. W. Lytle, *Chairman*, R. T. Kent, *Vice-Chairman*, Geo. E. Hageman, *Secretary*, Park T. Sowden, W. L. Conrad, and Robert E. Newcomb

THE tendency of manufacturers to employ their own engineers to carry out the details of management has resulted in a distinct cessation of controversy and of prejudice against scientific management. In fact, the principles of scientific management have spread much more widely under these conditions than ever before. For instance, the principle of preplanning in the form of budgeting is now universally accepted and is accomplishing great benefit. The same principle under the name of "sales quotas" is being used to an increasing extent to assist the rank and file of sales managers, and is doing much to harmonize sales with production. Furthermore, these principles are extending beyond the old engineering type of industries and are becoming popular in industries less accustomed to engineering methods. Offices and retail stores are resorting to them, not to mention the many special industries which formerly had no engineers at all. This has resulted in a demand for better personnel everywhere, and in more stable conditions throughout the year. The city-manager idea is apparently spreading. Many of these men are engineers and are doing much to solve traffic problems. In the type of industry which has always employed engineers, present progress has taken the form of minor refinement rather than of innovation. Distribution, which has had less attention than production in the past, is now being studied by many engineers.

FINANCIAL

Following a period of bad price fluctuations, we are now enjoying an era of decreasing prices and ample, decentralized credit. There has been a distinct discouragement of speculation and a decrease in non-voting stock. Brokers' loans are being published, and some cities and states are attempting to protect small investors from unsafe investments. The Government is pursuing the policy of decentralization with interstate control. While some railroad mergers have been denied, the general principle of merger is being encouraged. Stock ownership has been carried so far as to make a large number of employees actual capitalists.

Cost keeping is being standardized and put on a more comprehensive basis. It is now recognized that unless sufficient amounts are put back into business regularly, there will eventually come unexpected expenditures which may entirely absorb profits. Greater allowance is therefore being made for reserves.

MARKETS

While America is securing some foreign trade of the mass-production type, Europe and especially Germany is taking the bulk of that which involves small-lot manufacture. Our own southern districts are developing rapidly and are demanding both capital and experience in management. The Federal Purchasing Board, under the Bureau of Budget, has recommended a comprehensive program for Government purchases by which it hopes to obtain lower prices on the supplies required by the Government. The Board plan includes the creation of a revolving fund which will permit concentration of its vast buying powers in consolidated purchasing and entering of the markets at seasonal times.

The typical American company is carrying lower inventories. By using the order-point principle, purchasing agents are getting a more rapid turnover of money with less waste of material. Better transportation has also facilitated this matter. It is claimed that in one large plant the inventory turnover is daily. The term "purchasing engineering" has come into use in a few large companies where specification work is technical.

The Department of Commerce and the Ford Motor Company have each put out a proposed uniform invoice blank, and efforts are now on foot to combine the good points of the two and recommend a single blank. This is mentioned as typical of a tendency toward uniformity and simplicity of forms.

AVIATION

The Report on Civil Aviation has cleared the atmosphere and shown that air transportation is practicable under proper conditions. The Air Mail has developed during the past year through the addition of feeding lines to the main New York–San Francisco route. Secretary Hoover has stated: "There is promise of more rapid development than our best hopes. This is especially true in the Pacific Coast and Rocky Mountain States, because of the

great saving in time between long distances which commercial aviation will afford."

Two purposes will be served by commercial aviation, according to Secretary Hoover. "The first," he said, "is the speedier transportation of goods, and the second is defense." There are now about 150 planes in use throughout the country carrying passengers, express, and mail. Mr. Hoover predicts there will be 500 or 600 planes in operation for commercial purposes within the next year.

Organization

There seems to be a tendency toward smaller boards of directors and to the selection of members for what they can contribute in experience rather than in finance only. Directors are using committee methods and the professional manager is the rule, with more delegation of authority all down the line. Coördination and integration of functions is more thoroughly attended to than formerly. The education and development of personnel is being given greater consideration, and most large corporations now have educational departments.

Labor Relations

High wages and high production, have brought about more favorable labor relations here than in other countries. Some one has called this principle the "Gospel of Work and Optimism." The *Daily Mail* Trade-Union Mission to the United States called it the policy of "high wages as a forerunner of greater and cheaper production and consequently greater consumption and prosperity." This mission of "engineering" employees from England visited many large plants between Chicago and New York during March and April, and were most complimentary to us in their report. The things which they report as most surprising to them are:

1 Rapid turnover of capital, involving small unit profit
2 The large size of manufacturing units and their highly developed organizations
3 The readiness to scrap equipment when better is available
4 The large amount of power available on the average per employee ($3^1/_2$ to 4 hp.)
5 The accessibility of higher officers to employees, and promotion by merit
6 Profit sharing, holidays with pay, suggestion systems, and joint conference committees
7 Guaranteed wage rates and absence of any maximum wage
8 Absence of unemployment and of suspicion
9 Excellence of sanitary conditions
10 Lack of long apprenticeship periods.

This mission is now to be followed by a governmental mission representing the employer and consumer as well as the employee.

Safety

While employee committees have done much to secure cooperation in safety work, it is becoming apparent that the management must take the responsibility. It is also becoming accepted that the efficient factory is a safe factory. Good management and good safety work are consistent. A committee of the American Engineering Council has recently been making a survey along this line and will report early in 1927. One large corporation having branches all over the United States showed a gain in productivity of 25 per cent over four years and at the same time a drop of 60 per cent in accidents. Practically all successful employers now agree that safety work pays in dollars and cents. There is still a need for the standardization of safety statistics so that comparisons can be easily made. A few insurance companies are taking steps in this direction, notably in New England.

Elimination of Fatigue

This matter has had more propaganda than research. In a general way conditions have improved and unnecessary fatigue has been lessened. The tendency toward a wider division of operations permits a closer study of methods, but there has been practically no advance in our knowledge of the nature of fatigue and the part it plays in efficient production.

The use of electric arc welding (endorsed by the Bureau of Standards) to displace riveting in building construction may tend to eliminate one of the greatest sources of noise. Other studies being made may lead to the lessening of noise. Instruments have been devised to measure noise, and it is being demonstrated that noise is not necessary for speed.

Financial Incentives

There has been a revival of interest in this subject. Literature is again becoming voluminous, but of a more analytical and constructive type. Group bonus has become common, especially in the automobile industry. Some of the early applications of this plan were merely short cuts toward standardization of performance, and involved considerable injustice. These dangers are becoming known and are being successfully avoided. The prejudice which formerly existed against piece work has lessened, as such rates have been guaranteed and employees are learning that piece rate gives them *all* of the wages saved from decreased time.

Simplified Practice

The Simplified Practice Division of the Department of Commerce grew out of the Hoover Waste Report and has provided a medium for competing manufacturers to use in the working out of agreements, which was formerly impossible where no association for the trade existed. The reduction of the number of styles, varieties, and sizes is almost beyond belief in many cases. The most significant development in this work is the formation of a group of electrical manufacturers, 270 in number, doing an annual business of a billion and a half dollars. Gerard Swope, president of the General Electric Company, is president of their board of governors. It involves some of the largest corporations in the country and will attempt a restandardization of all electrical apparatus. Standardization itself is spreading to all types of industry. If the product is built specially, then many of the sub-assemblies or parts are standardized and assembled differently in the special units. This practice permits the use of mass-production methods to some extent in every kind of factory.

Engineering Education

Under the auspices of the S.P.E.E., Mr. Wickenden is making what will probably be the most exhaustive survey of engineering education which has ever been made. It will cover every phase of the subject and should prove of benefit in raising all colleges to a more uniform standard of excellence.

In this connection it is worth noting that in the second series of S.P.E.E. reports issued last summer, in answer to the question, "Should engineering students receive specific instruction in the realm of administration and management?" 58.5 per cent of the engineers and 58.2 per cent of the teachers responding replied in the affirmative.

The Coöperative Plan, in which students obtain practical experience during their undergraduate work, now embraces 10 per cent of all engineering students in the United States. It is lessening the awkwardness of college graduates in industry and is doing a great deal to fit students in to suitable opportunities with less annoyance to employers.

To meet the needs of colleges offering this kind of education there has been formed an Association of Coöperative Colleges comprising some twenty institutions. Herman Schneider, originator of the plan, is president of this Association, and the chairman of the Management Division is secretary.

Economics

In this field the United States has made a distinctive contribution. Mr. Ford and others have demonstrated to the world that it is possible to lower the price of the product and increase the volume of business, and at the same time to pay high wages and minimize slumps in business.[1] Europe is studying these developments, but has so far been unable to put them into operation. There is still room for improvement in educating the public in this field. There is a need of presenting fundamental economic principles in a simple way as a part of common-school education. Ford's announcement of a five-day week is a startling but natural result of higher productivity per machine and per man-hour.

[1] See Today and Tomorrow, by Henry Ford and Samuel Crowther; also article on Mass Production, by Henry Ford, in the 13th edition of Encyclopedia Britannica.

It will receive much thought in the coming year, although Jenkins Bros. have had this since 1922.

Events of economic importance that should be mentioned in this summary are: the formation of European steel trust, the collapse of the general strike in England, and the shifts that have taken place in American export trade, particularly in the field of industrial machinery.

As Management's Handbook could probably not have been written many years before 1924, so the formulation of the laws of management probably could not have been accomplished much before the present time. L. P. Alford's paper at this year's Annual Meeting is a distinct step forward in demonstrating that there are many principles or laws of common application to all sorts of circumstances. They should prove a most effective form of education in the economics of management. Management's Handbook is the first American handbook to be translated into German and French.

PSYCHOLOGY

The practical manager and the theoretical psychologist have been getting together. Each has discovered what he can learn from the other, and there is promise of much better placement of personnel than ever before. The fear that narrow specialization would be unwelcome or harmful to employees is subsiding under the circumstances of short hours, high pay, and excellent working conditions. In fact, the employee in America is treated better psychologically than in Europe.

RESEARCH

There has been a distinct improvement in the attitude of manufacturers toward research. Engineers are taking a prominent part in the furtherance of pure science. Secretary Herbert Hoover, first president of the American Engineering Council, headed a movement to raise $20,000,000 as an endowment for such work. Frank B. Jewett and Gano Dunn are among the engineers and scientists assisting. The first amount which Mr. Hoover raised for this purpose came so easily that he immediately doubled the budget. It is claimed that the application of science has outstripped the development of science itself. There is need for a great deal of pure scientific research in the immediate future. This will be facilitated by the fact that large companies have in the main gotten away from the policy of secrecy. The various units of industry are learning to coöperate with each other for this purpose, and are allowing their scientists and executives to take more part in the presentation of professional papers and the work of societies engaged in research.

General Motors and other large corporations have been studying their "non-productive materials" such as belts, metal cleaners, files, etc., and are finding that hundreds of thousands of dollars can be saved annually in such lines. The Waste Department of the Ford plant is most active and is reported to have effected an annual saving of $15,000,000. Research affecting more directly the public service is under consideration by the American Engineering Council, before which is a five-year plan framed by a special committee headed by Dr. H. E. Howe, representative on the Council of the American Institute of Chemical Engineers.

INDUSTRIAL MUSEUMS

There is a great need in the United States for industrial museums. Two museums similar to the Deutsches Museum in Munich and the Science Museum in London are assured in this country. The bequest of Henry R. Towne of more than two and a half million dollars assures one in New York City, and the work of organizing this museum is now under way. The splendid gift of Mr. Julius Rosenwald of three millions of dollars and a larger sum from the city of Chicago, insures a similar museum in that city. These two museums will prove of great educational value to the two largest industrial regions of the country.

INTERNATIONAL ACTIVITIES

Following the success of the first Congress in Prague in 1924, a second congress was held in Brussels. This, however, was not as international in its representation nor as influential.

A Third International Congress for Industrial Management is being planned to be held in Milan, Italy, September, 1927. The A.S.M.E., together with other societies has appointed H. S. Dennison as the American delegate and Morris Llewellyn Cooke as alternate. There is also being planned an exchange professorship in Management between Czechoslovakia and the United States. The Management Division will participate in the choice of the incumbents.

Dr. Edwin W. Kemmerer, professor of economics and finance, Princeton University, was invited by the Polish Government to head an American committee to investigate industries in Poland. This committee consisted of Harley L. Lutz, of Leland Stanford University; Joseph A. Broderick, vice-president of the National Bank of Commerce of New York; Joseph T. Byrne, expert in accounting and financial and business organization; Frank A. Eble, specialist in customs administration; Wallace Clark, expert in industrial management; and Frank D. Graham, associate professor of economics at Princeton University, general secretary of the committee.

Not only have there been several groups here from Great Britain to study American methods but also groups from other countries. Japan, for instance, sent Dr. Masawo Kamo, dean of the mechanical engineering department, Tokio University, and president of Kosei-Kwi, a society for the study of scientific management, with 5000 members.

MANAGEMENT WEEK

Management Week had for its subject Progress in Waste Elimination. This was chosen on account of its being the fifth year following the report of the Committee on Waste. This project is being sponsored actively by the Simplified Practice Division and is being used with considerable success as a medium of education and stimulation. There were meetings in over 200 cities, and the National Committee reports better interest than ever before, especially on the Pacific Coast. Some cities used last year's Management Week material as a basis for meetings throughout the whole year.

C. W. LYTLE, *Chairman*

Progress in Materials Handling

Contributed by the Materials Handling Division

Executive Committee: James A. Shepard, *Chairman*, R. H. McLain, *Vice-Chairman*, P. E. Stotenbur, *Secretary*, James Leroy Haynes, Geo. E. Hageman, and Robert Brooke Lea

THE FOLLOWING detailed account of progress in the materials-handling industry for the year 1926 is submitted with the emphatic statement that it is incomplete in its scope and in its details. Next year an attempt will be made to have this report cover a far greater number of machines and industries, as well as cover them in greater detail. It is only fair, however, to say in behalf of the Committee that if they fully reported on all of the improvements in the materials-handling affairs, they would have to deal with practically every wide-awake industry in the whole country, and obviously this is impossible and not to be expected. There have undoubtedly been many notable advances made which are not recorded in the following paragraphs, and for this apologies are offered to those interested.

BELT CONVEYORS

There has been further improvement in the design of belt-conveyor equipment during the year 1926. Enclosed drives, instead of open drives, roller bearings for idlers and pillow blocks,

and other similar improvements are being made. Belt conveyors have extended their usefulness in the way of greater refinement in manufacturing by coöperating with various process machinery. For example, they are used in connection with dry-cleaning processes for coal as compared to the older method of flotation. They are used for cleaning coke and for greater refinement in the segregation of stone. The use of belt conveyors as an aid in manufacturing in quantity production in such industries as the radio, and the typewriter, as well as in foundry processes, is being extended. By this is meant the method of putting a group of employees alongside of a flat belt conveyor and of so arranging matters that the article to be manufactured is worked on progressively as it passes by the employees. To some extent, belt conveyors are replacing cars in coal mines, and flat conveyors are being used in a great many industrial plants for handling packages where other methods were previously used.

CABLEWAYS

Alternating-current control has been developed to give power and plugging in both directions for application on cableways to get electrical retardation to slow speeds in each direction. This saves wear and tear on brakes. It has been installed at the Canadian Asbestos Company's plant in Quebec on two 450-hp. cableways.

CAR DUMPERS

Car dumpers for dumping open-top railroad cars are being steadily enlarged in size and improved. The first car dumper with Ward Leonard control was put in operation successfully at the T. & O. C. R. R. dock at Toledo. Over 4 million tons have already been dumped at a power consumption of 0.27 kw-hr. per ton. Complete Ward Leonard equipment is to be installed to electrify the fastest steam-operated dumper on the lakes located at Conneaut and operated by the Pittsburgh and Conneaut Dock Co. Direct-connected steam engines, instead of geared engines, have been put into operation with consequent elimination of gears with their noise and vibration.

A large number (nearly 200) of car retarders with full electric operation have been installed. These automatically retard cars to proper coupling speed after they have gone over the hump and do away with all car riders. They have been installed in the Illinois Central and other railway yards.

STORAGE-BATTERY VEHICLES FOR USE INSIDE OF BUILDINGS

This type of equipment has continued going hand in hand with the various industries which it is serving. It is now used to a greater extent in handling roll paper in paper mills and tin plate in the steel industry. Elevating-type trucks have been increased in size during the year from 6000 lb. capacity to 20,000 lb. capacity, and the attendant problems of reducing strain on the floor being traversed have been overcome.

LOCOMOTIVE CRANES

This year has seen the installation of a 25-ton storage-battery-operated electrical locomotive crane, the use of the caterpillar-type locomotive crane for construction work on subways and other places where railroad tracks are not available has been vastly extended, and gasoline drive successfully adopted on cranes as large as 25 tons.

AUTOMATIC HOISTS AND LARRY CARS

There is an increasing tendency toward the use of fully automatic skip-hoist mechanisms for handling coal and ashes, and toward the production of heavier machinery and harder work for the machines. A further development of this same type of equipment has been the automatic larry car, for transferring coal between a skip hoist and yard or between a bucket crane and yard without the use of any manual labor whatever. For extremely large automatic hoists, electrically driven, the Ward Leonard system of control has been used to give the refined speed control required for automatically lining up the hoist cradle with the track so that a car can roll on to the hoist cradle without jar.

COAL-MINING INDUSTRY

Machines have been developed for cutting and loading coal without the use of hand labor, and the remarkable stimulus that this has been given by joint meetings of the Materials Handling Division, the National Coal Association, and the American Institute of Mining and Metallurgical Engineers, is worthy of note.

During the past year a number of mines have developed and built for themselves short portable conveyors for loading coal after it has been shot from the room floor into the cars. These have been very successful and in some cases have doubled the speed at which coal can be handled. There has been developed also by C. L. Watkins, of the Pennsylvania Coal & Coke Co., a room scraper which is a bucket-type scraper dragged across the floor of the room by a stationary hoist, and which is so designed as to drag the coal up an incline and deposit it in the car. This scraper will drag up to two tons of coal at a time, and has proved a very economical device.

The electrification of shovels has proceeded at a rapid rate, and one of the advantages claimed for such shovels is their low cost of operation and maintenance. Some very striking figures are cited in this connection by electric shovel manufacturers, but the matter of comparative costs may be still said to be open for discussion.

Some years ago the Frick Company installed an unusual conveyor about five miles in length. This has been so successful that the company is now considering a second one, approximately three miles in length, which will probably be ordered at an early date.

FOUNDRIES

Noteworthy results have been accomplished with automatic handling apparatus in connection with other machinery in foundries, especially those which do a large volume of one kind of work as for automobiles and printing-press machinery. In one case very complete equipment has been furnished for handling the sand for a foundry from its receipt at the railroad siding right through its repeated use in the foundry, including automatic steaming, tempering, and conveying. Mold-handling systems have been installed involving the placement of molds for the molder, facilities for continuous pouring, automatic knock-out rigs, and delivery to stock or renewal of the operating cycle.

Completely reorganized manufacturing methods have been set up for the production of electric irons, electric ranges, and safety switches largely by the use of materials-handling equipment. Many an equipment will pay for itself, as in the case of that for electric irons, in two years and at the same time make possible a reduction in the retail selling price.

PLANT DESIGN

It now seems to be a pretty well-established fact that the most modern plants in many industries are designed around the materials-handling facilities. This is notable in the case of some of the latest foundries, which might of course be expected, but of late this principle has been extended to other fields: for example, the modern steam laundry is also designed around the materials-handling system.

FREIGHT ELEVATORS

There have been no outstanding developments this year in apparatus used for the vertical transportation of materials.

While there have been quite a number of detailed improvements of apparatus, the most important, perhaps, being the introduction of automatic car safety devices for platform-type elevators using multiple suspension and no car sling, none of these improvements can be considered spectacular.

On the other hand, there has been quite a marked tendency to handle freight on and off elevators in a more efficient manner. Automobile trucks, and also hand and power four-wheel trucks, are more than ever being handled direct on freight elevators, and a number of methods for handling loaded freight cars directly on elevators have been planned.

In freight elevators the old hand-rope control has been almost entirely supplanted by switch and push-button control, and the demand for the latter type of control is rapidly increasing.

With loads being handled on wheels and with higher elevator speeds being used, automatic leveling is coming more and more in vogue, particularly in connection with push-button elevators, where its use is essential.

Progress in the Woodworking Industries

Contributed by the Wood Industries Division

Executive Committee: William Braid White, *Chairman*, Paul H. Bilhuber, *Secretary*, Sern Madsen, James S. Mathewson, and Thomas W. McNeil

THERE can be no doubt that the principal features of the present year in the woodworking industries may be summarized under the two words conservation and mechanization. There has been a steady growth of understanding that the timber stand remaining in the country is not inexhaustible, and, in fact, as to certain important species is rapidly becoming what can only be called critical, speaking from the standpoint of the industries which fabricate articles of commercial use from native timbers. It is of course necessary in this case to distinguish sharply between the interests of the fabricator and those of the lumber manufacturer. What spells prosperity or contentment for the one in the present state of the supply of native timbers does not necessarily have the same meaning for the other.

Conservation of Supplies

The recognition by wood-using and wood-working industries of the impending crisis in lumber supplies has resulted in the formation of the National Committee on Wood Utilization, appointed by Secretary Hoover of the U. S. Department of Commerce. The object of this committee, which numbers among its members representatives of wood-using industries, forest-products engineers, and members of the engineering societies, including the A.S.M.E., is to investigate waste in wood fabrication, discover what can be done to minimize this, and carry on a campaign of education throughout the country which shall lead to the adoption of more efficient methods of handling and dealing with lumber, whether in sawmill, furniture factory, or elsewhere. To this end the committee is considering a variety of important topics relating to standards of grading, to standards of cutting, to the use of standard dimension stock, and to improved methods of handling and machining. At a meeting held in Washington on April 20 last, the committee was divided up into sub-committees, and these are now working upon plans for the better formulation of conservation policies in the utilization of lumber, beginning at the factory or the mill where the operations of transforming raw wood into wood products take place. There can be no doubt that, under Mr. Hoover's benevolent supervision, educational work of the highest importance will be carried on for the purpose of teaching the manufacturers the virtues of conservation at the machine. It is as yet too early to say what the results of the present year's work are likely to be; but it may be confidently affirmed that the question of conserving a diminishing supply of native timbers is being taken up in a practical manner calculated to capture and hold the interest of the manufacturing industries concerned. Along this road, of course, lies the only hope for genuinely useful work in this vital matter.

In this connection it might be well to remark that the Wood Industries Division is represented on the National Committee on Wood Utilization in the person of its chairman, by a special appointment from Mr. Hoover.

Research Projects Now Under Way

Along with this general movement toward conservation in the use, as distinguished from the production, of lumber, the Wood Industries Division has been active in promoting practical and important researches which are now in course of execution under the direction of the main research committee of the A.S.M.E. One of these is into the properties of machine saws and cutting blades, and its object is to investigate the mechanical laws which govern the behavior of these tools, and thus to formulate recommendations looking toward closer agreement among makers and users in the matters of saw cuts, sharpening of teeth, standardization of cutting edges for various purposes, etc. The work is being carried out by a committee of practical saw makers, knife makers, and engineers. It need hardly be pointed out that this research represents a very definite contribution toward a science of woodworking.

A second research is being carried out on the important question of tropical woods and their possible availability as substitutes for native species which are becoming scarce or of poor quality. In carrying out this investigation special thought is being given to determining the physical properties of the largely used native species, and to discovering in what, if any, tropical species available for American use such properties are reproduced to a practically satisfactory extent. The whole question of supply and commercial availability is also being gone into.

A third research is being carried out into the relation between forest fires and spark-arresting devices. The assistance of Student Branches of the Society on the Pacific Coast is being obtained, and there is good reason to expect that much will be learned as to the principles which should govern the design and construction of devices intended to consume sparks emitted by steam and internal-combustion engines used in or near tracts of standing timber. This also is a very important matter.

Woodworking Education in the U. S.

It is not possible to say what results may be expected to follow the inquiry being made under the same auspices into the status of woodworking education in this country. It is unfortunately still true that engineering colleges and technical high schools have to be taught (almost from the ground up in most cases) that the woodworking industries are rapidly taking their place, of necessity, among the engineering groups. Only when this fact has become patent to all who have in their hands the training of mechanical engineers, may we expect to be able to report adequate progress in this essential matter. Meanwhile the inquiry which has been made into the status of woodworking education in the U. S. A. through the Research Committee of the A.S.M.E., is bringing the facts to light.

Developments in Woodworking Machinery

Turning to the general question of mechanization, which was said at the opening of these remarks to constitute one of the two great features of woodworking progress during the year now drawing to a close, there is much of very great interest to report. Papers read before the Spring Meeting and Autumn Regional Meeting sessions of the Wood Industries Division have shown that further radical development of woodworking machinery is under way. The whole tendency is to create machinery for sawing, cutting, trimming, shipping, jointing, etc. which shall enable the manufacturer to approach the standard of precision in measurement and operation now common to the metal-working industries. Thus woodworking machinery is approaching the stage of multiple operation, where one machine performs two or more operations. Such machines already designed and in use are the combination jointer and planer (Oliver), the combination edger and jointer (Muskegon), the combination rip and jointing saw (Yates and Mattison). Then in machinery for performing machine-tool work on wooden machinery parts we have multiple hollow-chisel mortisers. In sash-and-door manufacture, double tenoners, double cut-off saws, etc. are coming rapidly into use.

Power feed for shaping machines is coming also into use and has been largely adopted during the year in piano, furniture, toy, and similar shops.

The adoption and use of portable electric-drive machines have been features of the year. Such machines are drills and saws which can be carried about and handled by the individual operator just as the ordinary hand tools are used. The adoption of these is coming to revolutionize the conditions of skilled labor in piano and cabinet shops. Then again, compressed air for driving drills,

saws, routers, and milling and boring machines is coming largely into use, and air cleaning with compressed-air tools is superseding the old-time hand methods, to general advantage. All along the line the above-noted tendency toward multiple operation is to be observed, multiple drill heads and multiple borers of large size are becoming common. Notable examples are to be found in piano, piano-action, and piano-player-action shops.

In line with the tendency toward more scientific development based on such researches as are mentioned above, we find that band and circular saws are being made for higher speeds and of thinner, more efficient steel, thus tending to promote conservation by eliminating saw-kerf wastes, etc. Speeds and feed rates are generally on the increase, which shows a healthy tendency in the right direction.

Similar improvements are being seen this year in cutting knives as used on molding machines, etc., where high-speed steel is being used for thin knives which require no grinding. The whole movement is evidently in the direction of smoother cutting and smaller wastage.

In line with the growing consciousness of need to develop the commercial use of non-native woods, in view of possible exhaustion of native supply, an increasing use of fancy tropical hardwoods in veneer form is to be noted, especially for high-class furniture, pianos, etc.

Investigation of Wood Finishes

Meanwhile there is opening up an entirely new field of investigation, exploitation, and use in the domain of wood finishes. Lacquers, which began to attract attention as applied to wood finishing only within the last year or so, have come more and more largely into use as the technical problems of manufacture and application have one by one been solved. The importance of the subject is indicated by the decision of the Wood Industries Division to devote its session at the Annual Meeting of the Society this year to what is in effect a symposium on the whole question of wood finishes.

The native hardwoods used for cabinet work, veneering, etc. are still popular, especially walnut. Of the native softwoods, the reign of chestnut seems to be very nearly over, owing to the spread of the blight, which so far has not been checked by any agency or method known to forestry science.

Plywood continues to grow in popularity as a superior substitute for solid wood in boat building, box making and furniture manufacture. For many years it has been an essential component of piano construction. Wood waste is coming to the front in the shape of pressboard and similarly fabricated material, and is being used in building construction for paneling, partitions, siding, etc.

Some of the developments just mentioned owe their existence to the improvements which have been lately made in the application of casein glue. During the year this use of this adhesive has been considerably enlarged.

Lastly, the field of wood uses has been once more extended by the notable movement in freight-car construction toward a composite structure with steel frame and ends with wooden sides in place of the all-steel body which at one time seemed likely to supersede all other forms.

It appears, all in all, that the wood industries of the country are keeping up with the metal industries in the application of scientific research and of engineering principles, so far as the difficult nature of their raw material will permit. More and more progress of the kind may be confidently anticipated, toward which the Wood Industries Division of the A.S.M.E. expects constantly to contribute.

WILLIAM BRAID WHITE, *Chairman*

Progress in Petroleum Engineering

Contributed by the Petroleum Division

Executive Committee: W. R. Eckart, *Chairman*, H. R. Pierce, *Vice-Chairman*, P. L. Guarin, *Secretary*, Carl F. Braun, T. H. Kerr, and Walter Samans

DURING the past few years there has been very decided progress made in better design and application of oil-field equipment. Several of the large producing companies maintain well-organized mechanical engineering and research departments to study and analyze current production problems with the view of developing new and better methods and equipment to aid in the production of oil and gas. The purchase of new material and equipment by these companies is usually based upon the recommendations of the engineers, made to the management in the form of very complete analytical reports.

Standardization Work of the American Petroleum Institute

Perhaps the greatest single coöperative advancement made by the oil industry has been the work that the American Petroleum Institute has accomplished on Standardization of Oil Drilling and Production Methods and Equipment. Complete specifications have been drawn and adopted, or in some cases tentatively adopted, on the following material:

Steel and Iron Pipe for Oil-Country Tubular Goods
Oil-Field Belting
Sucker Rods
Standard Rigs and Derricks
Rig Irons
Cable-Drilling-Tool Joints
Oil-Field Boilers
Rotary Drilling Equipment
Rotary-Drilling-Tool Joints
Wire Rope
Manila Cordage
Standard-Size Bolt Holes for Engines
Flange Connections Between the Clutches and Gas Engines.

The work of several of the Standardization Committees cannot be completed until additional tests and research work have been conducted. Funds have been appropriated for this purpose and allotments are being made to the various committees for carrying on this work.

Seamless Steel Pipe and Tubing

There has been a phenomenal increase in the use of seamless steel casing and tubing, and even line pipe, in the oil fields. The grade of steel used in the manufacture of seamless pipe is considerably higher than that used in the manufacture of the welded product. This permits the operator to carry the seamless strings of casing to greater depths, without sacrifice of safety factor, than was possible with welded pipe. Sizes of the seamless product, up to 10 in., can now be purchased on the open market, while the larger sizes are still in an experimental stage. However, some companies have successfully made these larger sizes and are furnishing them on special order for mill shipment.

Application of Automotive-Type Gas or Gasoline Motors

Automotive-type power units in sizes from 20 to 120 hp. are being used in increasing numbers for a variety of power purposes in the oil fields. The portability of these units is a very desirable feature, and they are being used to replace the heavier steam equipment and boilers on both cable-tool and rotary drilling rigs, especially in localities where there exists a scarcity of water, which is very often the case in "wildcat" operation, or in new fields where the quantity of water available is insufficient to supply the demand.

The low cost of operation of these units, especially in cases where natural gas is available, is perhaps the greatest reason for their increased use. Actual comparative operating costs show

that they can be operated at a fraction of the cost of operating steam equipment and will run considerably lower than the heavier types of slow-speed gas and oil engines and in some cases have shown lower operating costs than obtained with electrical power.

Some notable applications of high-speed automotive-type motors in the oil fields are as follows:

Drilling with rotary rigs—used to drive both the draw works and the slush pumps
Drilling with cable-tool rigs—used with portable drilling machines and with the standard rigs
Driving air and gas compressors
Driving reduction-gear units for pumping oil wells
Driving clean-out and pulling machines
Pulling rods and tubing
Driving water and oil-line pumps.

Reduction-Geared Pumping Units

In order to decrease the operating costs on wells ordinarily pumped with a standard rig, some operators are installing reduction-geared pumping units, driven with either electric or automotive-type motors. These units deliver the power directly from the motor to the pitman without the use of belt or chain for the transmission of power. On the standard rig the belt and other maintenance costs run very high, especially on deep wells. The installation of reduction-gear pumping units allows a large part of the standard rig to be salvaged. In order to pull rods and tubing a chain-driven hoist is installed which is driven from a sprocket on the reduction-gear unit, or in some cases this is accomplished by using a tractor equipped for this work. Perhaps the most serious disadvantages of the reduction-gear units are the limited speed-power range and the inconvenience encountered when cleaning out with tools becomes necessary.

Hydraulic Long-Stroke Pumping Units

The hydraulic pumping units were designed primarily to pump deep wells capable of producing large amounts of fluid. Strokes of from 9 to 12 ft. are possible with these units, and production as high as 1000 barrels a day or more is obtained. The standard rig is left intact for pulling and cleaning-out work. The power required to drive these units runs considerably higher than the ordinary requirements, and the gas engine with which the standard rig is ordinarily equipped must be replaced with a much larger engine. The power is transmitted to the pump, which is set on the derrick floor, by means of a chain drive from a sprocket which is installed on the band-wheel shaft.

Trend of New Cable-Tool Drilling and Pumping-Rig Development

The need is apparent for a cable-tool drilling rig which can be left intact to serve as a pumping unit, that will eliminate the use of belting, that will function exactly like a standard rig for drilling, pulling, and cleaning-out purposes, and that will serve to accommodate long-stroke and power requirements for pumping large amounts of fluid from deep wells. Several attempts and experiments are being made at this time to develop a chain-driven drilling and pumping unit which will replace the present standard rig and the costly pumping units.

Pumping Deep Wells from a Central Power

The economy of pumping a number of wells over 3000 ft. in depth with the central pumping power has been generally less than anticipated. Many jacks do the work successfully for a short period of time, and then they become a source of considerable expense to keep in repair. Generally speaking, they are not sufficiently sturdy and the strokes obtained are not long enough. Regardless of the mechanical detail of any jack, means should be provided for counterweighting a large part of the well load, and the counterweight should be made adjustable to suit conditions of loading. Due to the enormous loads that the jacks must handle in pumping deep wells, a firm and solid foundation is necessary. This is very difficult to obtain for types of jacks that have to be placed on the derrick floor, especially where it is inadvisable to fill the cellar. When pulling rods and tubing, or when cleaning out, it is desirable to have the derrick floor clear. A type of jack that is placed outside of the derrick floor and uses a walking-beam principle to carry the balancing load, has proven very successful, especially for strokes of 36 in. and longer.

Air or Gas Lift

The method of producing oil by means of air lift has been employed for several years, but more recently the use of gas lift has come into prominence. Gas in preference to air should be used when it is possible to do so. Dry residue gas from the casinghead plants is generally fed to the compressors from the field residue line. However, in some cases it is delivered from the high-pressure accumulator directly to the high stage of the compressor, which of course is only possible in cases where the gasoline plant happens to be of the compression type and conveniently situated. Air is slightly soluble in oil and natural gas five times more soluble than air, while dry residue gas is seven times more soluble than air. The wet gas produced with the oil is separated from the oil in a gas trap and the gasoline extracted at the casinghead plant. The dry gas is then recompressed and used to lift more oil. The recycling of the gas will also result in an increased gas production. All reports of practical operations have shown that the volume of wet gas increases with the use of the gas lift.

In cases where no gas is available, or is not economically available, and where there are no casinghead plants to consider, air may be used with good results.

Restoration of Pressure to Stimulate Production

Restoration of pressure to producing oil and gas sands to increase the production has been applied extensively during the last fifteen years, and probably 4000 wells have been affected in the Appalachian fields of southeastern Ohio and the northwestern part of West Virginia. As a matter of fact, restoration of pressure to increase the production of oil sands was known before 1880, as evidenced by a book published that year by Dr. John F. Carll, of the Pennsylvania Geological Survey, entitled The Geology of the Oil Region of Warren, Venango, Clarion, and Butler Counties. More recent history is found in the records of the use of gas and air for pressure restoration in the oil fields of Oklahoma and Kansas. It is apparent, from the success attained thus far, that this practice will become quite common throughout the Mid-Continent fields.

The commonly accepted theory of technical men and operators who have experimented with gas is that through the increase in pressure, additional gas is absorbed by the oil, which decreases the viscosity of the solution, thereby permitting additional movement of the oil toward the wells; additional potential energy is added to act as an expelling force to drive the oil through the sand and when released by approach to the hole, carries additional oil into the well.

Both air and gas have been used, but gas should be used in preference whenever possible to do so, because the gas reduces the viscosity of the oil and is the natural medium to produce the oil. Danger of explosion of the casinghead gasoline plants is reduced and greater economy of methods will result. The restoration of pressure to oil-producing horizons is not only a process of production which will increase both oil and gas, but a true measure of conservation which will allow a total recovery far in excess of recovery under present methods of production.

Need for Research

Other branches of the oil industry for many years have maintained competent research departments, but the producers in the past have been content to get along with the best methods and equipment available, probably due to the fact that the economic pressure in the production of oil has not been as great as encountered by the other departments. However, lately the production men are looking more and more at operating costs. Such items as wire lines, belts, sucker rods, etc. constitute major expenditures under operating expenses.

Wire Lines. The present life of wire lines in cable-tool drilling and swabbing service is entirely too short. Detailed study of the wire-line situation has revealed the fact that the life of a wire line in these services depends largely on the life of the core material. Salt water and other destructive agents encountered in an oil well

deteriorate the manila-core material very quickly, allowing the strands, under enormous pressure, to crush out the core. When the core is gone the strands are not provided with anything to hold them in their proper places, with the result that they pull in together, allowing the lay of the rope to reach three or four times its original length. For strictly hoisting purposes the independent wire-rope center appears to be a good substitute for the usual hemp core, but this makes a very stiff rope, unsuitable for cable-tool drilling purposes. There is need for research in developing a better core material, which, when made into the finished rope, will provide permanent and adequate support for the strands and at the same time retain the present elasticity.

Belts. One of the most serious handicaps in obtaining good service from belts used on standard rigs is the low belt speeds, and there does not appear to be any convenient way in which to obtain higher belt speeds for this work. The A. P. I. Standardization Committee on Oil-Field Belting made a very close study of different types of belting commonly used in the oil fields. Some very interesting points were discovered. In most types of belting they found that the ultimate strength of a belt did not increase proportionally with the number of plies added. In fact, they found very little advantage in extra plies over the number most commonly used. It is therefore obvious that additional strength must be gained by using wider belts, which will necessitate changing present clutch-pulley, band-wheel, and other rig equipment to accommodate wider belts.

Recent experimental determinations of maximum belt tensions encountered in pumping 4200-ft. wells with a standard rig and ordinary pumping equipment were made by a party of engineers in the Tonkawa, Oklahoma, oil field. They showed that maximum belt tensions as high as 25 per cent of the ultimate strength of the belt are being encountered in this work, which is entirely too high for good practice.

The A. P. I. Committee also found that stitching decreases the strength of a belt very materially, and it follows that extra stitching over the minimum amount required should be avoided. They have also drawn elongation specifications for several classes of belting. The proper amount of stretch or elongation for belts will no doubt vary for different materials used, and will probably vary for methods of fabrication. It appears that there is no true, or even approximately true, elastic limit for a belt. However, there is undoubtedly need for further research on the subject of belt elasticity.

Balata belting possesses some admirable properties, and has been used with considerable success. However, the temperature at which the balata bond between the plies begins to lose its adhesiveness is rather low, and further research should be made with the view of improving the character of the balata solution in order to raise the temperature at which its adhesiveness is seriously affected.

Sucker Rods. Most of the trouble experienced with present sucker rods results from breaks usually occurring at the pin, which are undoubtedly due to fatigue. Some fatigue tests were recently run in which samples of special heat-treated carbon-steel rods showed fatigue qualities greatly in excess of any of the standard makes of rods now on the market. A few of the larger sucker-rod manufacturers are now experimenting with alloy-steel rods which are heat-treated throughout their entire length. It appears that merely normalizing the ends of the rod after forging is not sufficient, and that in cases where the entire rod is heat-treated there is considerable difficulty encountered in subsequent machining operations. There is very decided need for research along these lines to develop sucker rods of greater strength and better fatigue qualities.

Cement. In deep-oil-well cementation work the time required to place the fluid neat cement behind the casing is sometimes as long as two and one-half to three hours. For this reason a cement to be used for this purpose should have a long initial setting time. After the cement is once in place rapid hardening is very desirable. Several brands of cement are now on the market, which are claimed to be special oil-well cements, as well as numerous quick-setting compounds to be used as admixtures. Practically all of these cements have a low initial set, and all of the quick-setting compounds serve to decrease the initial setting time, as well as produce higher strength at early ages. There is need for oil-well cement that possesses a high initial set, and high strength at early ages of one to seven days.

It is a well-known fact that increasing the amount of mixing water produces a neat cement of lower strength. In oil-well cementation work we are obliged to use neat-cement mixes with a water ratio of approximately twice what would be considered good practice in surface work in order to obtain sufficient fluidity, that it may be handled successfully by present cementing equipment. Research along the lines of ceramic chemistry might produce a cement which would possess the necessary fluidity with the use of less mixing water, resulting in higher strengths of set cements.

The Natural-Gasoline Industry

Portable Gasoline Plants. One of the outstanding developments in the natural-gasoline industry during the past year has been the growth of portable gasoline-plant installations. It is conservatively estimated that all the portable plants in the Mid-Continent area are each producing an average of from 2500 to 3000 gal. of natural gasoline per day, while one portable plant of 2000 gal. rated capacity, owned by the Roxana Petroleum Corporation, has produced in excess of 8000 gal. per day. This was accomplished by passing large quantities of wet gas through the plant under large flush-gas conditions, the residue gas not being stripped to a gasoline content that would ordinarily be satisfactory.

The best application of the portable plants is in new fields having a large flush production of gas, where well pressure can be utilized for passing the gas through the absorber and where the gathering systems are limited. The first conception of the portable plant was mainly a plant of large economic value to serve as a stop-gap before a permanent plant could be erected, making possible the utilization of much of the gasoline content of the flush gas that otherwise would be wasted. However, good efficiencies obtained and general satisfactory operation of these plants have delayed the erection of the permanent plants. For the time being at least, many of the owners are installing compressors to force the wet gas through the absorbers when the operators remove the back pressure on the wells, so that in these cases the portable plants are being used in lieu of the permanent ones.

In line with this trend of application of portable-type plants there has recently been introduced a semi-portable plant of about three and one-half times the capacity of the usual portable plant. In effect this semi-portable plant is more portable than the so-called portable plant, inasmuch as it is mounted on three skids, while the latter plant of the same make is mounted on only one skid. In addition, it has the advantage of less initial-equipment cost per gallon of rated capacity. The portable plants are still in the process of development, and it is difficult to draw any conclusions at this time as to their probable future application. At least one of the largest users of portable gasoline-plant equipment is seriously considering the inclusion of compressor installations as a necessary capital expenditure when the plant is installed for handling the gas when back pressure on the wells is no longer maintained.

Absorbers

Equipment manufacturers who have been specializing on natural-gasoline-plant apparatus, have devoted a large part of their energies during the past few years to the development of absorbers which would give a high percentage of saturation to the mineral seal oil to reduce the amount of oil circulation. As the oil circulation is brought down it follows that a less expensive distillation installation can be utilized since the capacity can be reduced. With this development have gone forth improvements in the distillation equipment designed to strip the mineral seal oil of its gasoline with the lowest possible consumption of steam.

One type of absorber obtains high efficiency by breaking up the mineral seal oil into a fine spray and passing the gas through this spray again and again. Another company has produced a new counter-current bubble-type absorber very similar to the bubble tower which has been adopted by the refining industry within the past two or three years to supplant less efficient frac-

tionating equipment. This absorber has been adapted for use with a vertical steam still, and with a dephlegmator to knock back any mineral seal oil which may have been entrained in the gasoline vapor.

PROPANE REFRIGERATION PROCESS

A new refrigeration process which has been successfully applied to both compression and absorption plants has been developed by the Roxana Petroleum Corporation under the direction of S. C. Carney. For many years the value of lower condensing temperatures in the compression process has been known, and from time to time attempts have been made to use various processes of refrigeration to obtain condensing temperatures lower than possible to obtain by the circulation of cooling water. Probably the greatest difficulty in the past has been the inability of the manufacturers to hold the lighter fractions of gasoline condensed at low temperatures. However, since the advent of the stabilizer it is possible to fractionally distil the most volatile fractions and produce a finished product of high recovery.

Ammonia refrigerating plants have proved expensive to operate and are troubled with brine dilution, loss of refrigerant, and freezing. Propane is claimed to have an efficiency equally as good as ammonia when used as a refrigerant. This hydrocarbon is produced as a by-product of natural gasoline by the stabilizer.

The Carney process consists of drawing a very narrow cut of almost pure propane with a short boiling range from the stabilizer until the system is filled. The propane gas is compressed and then cooled by circulating cooling water and then further cooled by passing it through a heat exchanger in which the residue gas from the high-stage accumulator acts as the cooling agent. The liquid propane then passes to the refrigerating element, where the wet gas from the high-stage compressors is cooled to nearly 32 deg. fahr. The drop in temperature in the refrigerating element depends largely upon the latent heat of vaporization of the propane rather than upon expansion of the refrigerant, and the boiling temperature, and hence the condensing temperature, is controlled by application of back pressure on the propane gas in the refrigerating element. With the application of some dehydrating agent such as silica gel it is expected to run the condensing temperature in the refrigerating element considerably lower. This allows us to consider refrigeration in connection with the stabilizer as a valuable extension to the compression system, and holds for the future the probability that the propane refrigeration process will be developed to a point where the compression-plant residue-gas gasoline content will be reduced to compare favorably with the efficiencies obtained by the absorption system.

In applying the refrigeration process to the absorption system, the temperature of the mineral seal oil may be brought down as low as found to be economical.

ANTI-KNOCK QUALITIES OF CASINGHEAD GASOLINE

Natural gasoline has a distinct value as a blending material with straight-run gasoline to produce a non-detonating motor fuel. Drs. E. H. Leslie and G. G. Brown, of the Research Department of the University of Michigan, conducted an investigation for the Association of Natural Gasoline Manufacturers, to determine the non-detonating qualities of casinghead gasoline as a blending material. Briefly, they found that for up to 40 per cent blends of natural gasoline with straight-run gasoline, the natural gasoline was from one-half to two-thirds as effective as benzol. Maximum anti-knock effect as compared with benzol was obtained in 30 per cent blends of casinghead gasoline with straight-run gasoline. Benzol was selected as the base for comparison because of its well-known anti-knock properties.

The Midgley bouncing-pin apparatus designed by Thos. Midgley, Jr., of the General Motors Research Corporation, was used in the measurement of detonation.

Experiments were also made at the Marcus Hook Refinery of the Sun Oil Company by A. L. Clayden, who also used the bouncing-pin apparatus for testing detonating qualities of natural gasoline as a blending material with straight-run gasoline, using benzol as the base for comparison. From his experiments Clayden concludes that the relative value of casinghead gasoline as an anti-detonating blend is dependent on the anti-knock quality of the blend stock, and that it is easier to improve a blend-stock fuel with an initial good anti-knock figure of merit than it is to improve a blend-stock fuel with a lower initial anti-knock figure of merit.

Automotive engineers have pointed out that greater economy in gasoline motors is dependent upon higher compressions, and that it is up to the oil industry to produce a fuel having sufficient anti-detonating qualities to combust in higher-compression motors without causing detonation. It has been pointed out by C. F. Kettering, of the General Motors Research Corporation, that since 1921 the 50 per cent and 90 per cent over points on the gasoline distillation curves have constantly risen, although initial boiling points have been reduced, and that it is his opinion that modern gasoline is more detonating than in former years because of the inclusion of heavier ends.

As market demands for motor fuel increase, refiners will crack more heavily, produce a motor fuel of less volatility, and demand more natural gasoline to obtain an acceptable product.

REFINING

The year 1926 has been one of development of processes and equipment. Few, if any, radical changes have been made.

The improvements in stills have been largely in the detail. Pipe or tube stills have shown the most progress. New designs more fully utilizing radiant heat have appeared. (The new Cross heater.) By means of slight back pressure and high outlet temperatures it has been demonstrated that better-quality residual fuels can be produced from pipe-still skimming units.

Corrosion of the parts of distilling units has received attention, although definite conclusions as to the best materials have hardly been reached.

Fractionating practice has made a definite trend toward the bubble tower with automatic control. Opinion is still divided on the relative merits of a reflux condenser and a "pump in" for bubble-tower control.

Heat exchangers have been more widely adopted. Some unusual examples of vapor heat exchange have been installed. Crude feed temperatures of 350 deg. have been obtained from this source of waste heat.

The application of vapor heat exchange to batch reducing stills for lubricants has been progressive. By means of accumulators remarkable results are possible.

Pipe stills have seen a more diversified use. The circulating type, well known on cracking stills, has been applied to stills for reduction of lubricants and for running crude oil to cylinder stock. In one case this type of heater has been applied to a high-vacuum still.

While many cracking plants have been installed, a number of them replace obsolete equipment so that the gain in capacity is not as much as is apparent.

On January 1, 1926, there was a cracking-plant capacity of approximately 1,000,000 bbl. daily charge. The gasoline yield was approximately 300,000 bbl. The actual production of cracked gasoline in January was 218,000 bbl., showing that not all equipment was running to capacity.

The estimated production for the year 1926 is about 85,000,000 bbl. of cracked gasoline, or at the rate of 233,000 bbl. per day. The estimated conditions as of January 1, 1926, indicate a total cracking capacity of 1,200,000 bbl. per day, with a possible gasoline production of 300,000 bbl. per day. The probable actual gasoline production will approximate 250,000 bbl. daily.

Note that the increased throughput is offset by the decreased percentage yield. This is due to increased high-pressure operation for light ends, together with the material reduction in the end point of the cracked product.

Two points of interest in connection with cracking-still progress should be mentioned. First, the increase in capacity per unit. Plants are now being installed, each unit of which will have a daily charging capacity of 4000 bbl. Second, the increased use of the hot-oil pump. Reliability of pumping equipment at 1000 deg. temperature and high pressures has resulted in many installations of these pumps for the purpose of circulating the oil from expansion drums or dephlegmators back through the tubes. Better yields and higher capacities are the advantages.

The principal progress in vacuum distillation has been along the lines of capacity. We have had small, extremely high-vacuum stills for two or three years. This year has seen some excellent results from continuous-vacuum-still batteries. Jet condensers have been developed that give results comparable with mechanical vacuum pumps.

The question of pumping equipment seems to have no definite trend. Some refineries are going to motor-driven power pumps. This seems preferable only when the power load exceeds the demand for steam from the stills. As long as the exhaust can be utilized, the simpler and more flexible steam pump seems advisable.

Several refineries have installed new boiler plants with modern water-tube boilers. The tendency has been to increase the percentage rating at which boilers are operated.

The principal development in lubricating-oil treatment has been the rise of the "contact" method. Several thousand barrels of lubricants are being decolorized in this manner daily. The application of dry clay to primary distillation is being worked out.

Furnaces of the Wedge or Herreschoff type for the revivification of fuller's earth have supplanted the gravity and rotary kilns in new installations. It is reported that the life of the clay is at least doubled and that better yields of lubricants per ton at each burning are obtained.

New vapor-tight centrifuges for the removal of amorphous wax from lubricating stocks have been introduced. It is believed that they will materially reduce the fire hazard involved in this process.

Coöperative engineering service was undertaken by the one large oil association. Twenty of the members' boiler houses were analyzed, standards set up, and an educational program instituted for the force. A 27 per cent saving of fuel was found without any investment in additional equipment.

TRANSPORTATION

Pipe Lines. Transportation of crude oil between producing fields and ocean shipping terminals is still being carried on through pipe lines, if practicable, in preference to tank cars.

One of the latest fields to be developed, that of the Panhandle District of northwest Texas, is producing a crude that is particularly difficult to pump through pipe lines, on account of its high viscosity. The congealing temperature of this crude is about 55 deg. fahr. After considering the experience of the major pipeline companies handling this crude it appears that the best practice is to use large lines (not smaller than 6 in.), place the pump stations closer together, and heat the crude discharged from the pumps to temperatures as high as 120 deg. fahr. High-pressure heaters designed to handle a discharge pressure of 800 lb. per sq. in. are used for this purpose.

Marine Transportation. Oil will always be moved from California, South American, and Texas fields to the eastern seaboard by means of tankers in preference to pipe lines. This is evidenced by the continued increase in new tankers and reconditioned Shipping Board tankers.

With few exceptions the tankers added to the various comp'iesan fleets are Diesel-engine-driven. During the past year the Gulf Refining Company has added several vessels to its fleet, the largest being the *Gulf Crest*, of 13,000 tons deadweight.

They have also contracted with the Federal Ship-Building Company, for a twin-screw tanker having a deadweight of 17,500 tons which is to be equipped with Bethlehem engines. A number of companies are having built small tankers for bulk-station shipments of finished products.

The Atlantic Refining Company is converting three Shipping Board vessels to Diesel-electric drive. These tankers will be equipped with Price-Rathbun oil engines and General Electric equipment similar to that on their motorship *J. W. Van Dyke*, with the exception that each tanker will be equipped with three 600-b.hp. engines.

MARKETING

There have been very few developments in marketing methods or equipment during the year, the principal tendency in evidence being the use of larger trucks for station deliveries on account of the improvement of the main highways and the greater economy in the use of the larger-capacity units. Five-ton trucks are preferred.

The use of a trailer in connection with delivery of petroleum products is a decided economy, as the trailer tank has the same capacity as the main truck and can be operated at only a fraction of the cost of truck alone.

There is no legislation or weight limitation except that providing for tire width as given in highway-department specifications.

The use of chains for discharging static from petroleum-products motor trucks is being discontinued by some companies, as the hose used for loading and unloading has a metallic connection between the ends inserted in them.

The tanks on trucks are now built uniformly of welded construction, and riveting has been discontinued.

The truck tanks are supported on three- or four-point suspensions, depending upon the option of the user, but with the four-point suspension the trucks are rigidly strapped to the frame, and the whole construction needs to be more expensive to reduce weaving strains in transit.

No special metal is used in the construction of tanks with the exception of the transverse heads, which are made of flanged steel.

None of the later trucks have any wood in their construction; therefore their life is lengthened and the fire risk decreased to a minimum.

The use of household burners is increasing, and some oil companies are fostering their use with the intention of building up sufficient sales of fuel oils to warrant their making fuel-oil deliveries at prices comparable with coal. No prediction can be made, however, as to the number of years fuel for this purpose will be available.

Legislation in some states or cities preventing the installation of curb pumps, together with the excessive number of curb pumps in urban localities, is creating a tendency toward marketing through the oil companies' own service stations, as the present arrangement of furnishing tanks and curb pumps to any one applying for them is proving to be more expensive than the business warrants.

P. L. GUARIN, *Secretary*

Progress in Fuels Engineering

Contributed by the Fuels Division

Executive Committee: E. C. Schmidt, *Chairman*, S. B. Flagg, *Secretary*, O. P. Hood, Edwin Jowett, Victor J. Azbe, and John Van Brunt

SHIFTS in coal supply were more marked the past year than in any recent period since 1922 during the miners' strike. Except for a slight increase during the latter half of the anthracite miners' strike and until quite late in September, when the effects of buying for foreign account were felt, bituminous-coal prices have been at a low level. The average spot price has been more often below $2 than over, as compared with $1.25 ten years ago. Competition in the sale of coal since the fall of 1923 has been dominated in nearly all markets by the non-union producers of the South. The North has been buying more and more of its fuel from the low-cost non-union mines; the union mines of Pennsylvania and Ohio in particular have either closed, have been operated on short time at a loss, or have been fighting the union in an effort to reduce wages.

Pennsylvania is the leading soft-coal-producing state. Its normal output has been between 150,000,000 and 175,000,000 tons of

bituminous coal. Prior to 1923 West Virginia had a normal output of between 70,000,000 and 80,000,000 tons. In 1926, it now seems likely that West Virginia will exceed Pennsylvania in the production of bituminous coal. Eastern Kentucky has poured low-priced coal into northern industrial markets; Western Kentucky, now all non-union, has been giving Illinois mine fields severe competition. Coal consumers have been making the acquaintance of many heretofore unknown coals, many of which are of excellent quality.

The falling off in the use of petroleum and natural gas for industrial fuel use, noted in this report for 1925, continued through 1926. There was a steady record of oil-burning plants, with stationary and railway engines, converted back to coal firing. The tendency in the marketing of natural gas is to conserve supply by discouraging its use for industry, while encouraging its use as household fuel, at gradually mounting prices.

Education in coal consumption, forced during the post-war period of high prices, has proceeded. Every installation now looks for fuel economies and demands the highest quality of coal. Competition in the sale of coal has pushed this movement forward. Coal is being sold on a quality basis and is being bought that way. Fewer tons of coal are thus bought and sold, but more power is produced.

Coal producers are keeping pace with the more stringent demands of the user. Coal cleaning is getting more attention. The introduction of mechanical loading in the mines is forcing the producer in this direction, because a machine cannot select the material it puts in the pit cars, as the coal miner was required to do.

Air cleaning of bituminous coal has advanced the past year. No less than six large installations of air tables are being put in now. A new impetus to water cleaning has been given by the introduction of the Chance and Rheo processes, both of which have registered their principal advances in the cleaning of anthracite.

In the field of utilization of fuels, steady progress has been made in furnace design; the work in progress outlined in this report for 1925, notably along the lines of higher temperatures in combustion chambers, in water- and air-cooled furnace walls and in high pressure applications of steam, advanced in 1926. Several large installations, as the Avon at Cleveland, are using pulverized coal, but it can hardly be said that pulverized fuel is sweeping the field.

What has been most marked has been the advances made in the use of gas, both as household fuel and in the industrial field. The gas industry, and that means the artificial-gas industry, is pushing ahead as never before. Because of uncertainties as to supply and price of gas oil, and because of definite economies in the by-product field, the direction of gas manufacturers is toward by-product coke ovens. More than 4,000,000 tons of small sizes of by-product coke were sold in 1925 for household use. Coke, and to some extent low-volatile bituminous coal, is taking business away from anthracite as domestic fuel.

The anthracite strike of 1925–1926 opened the doors for the use of substitute fuels, particularly in New England and northern New York. The producers of coke and of low-volatile bituminous coal have consistently followed up their advantage and are taking on all the normal increase in domestic fuel demanded in the eastern territory.

There have been no notable developments in the field of low-temperature distillation of coal. In fact, as noted in this review for 1925, there is a tendency to divert research from distillation to complete gasification and the production of synthetic products as substitutes for gasoline. So far commercial operation has not been marked in this country or abroad on low-temperature distillation, whereas both here and abroad definite success has attended synthetic liquid fuel.

A notable gathering of technologists from abroad as well as of this country met in November, in Pittsburgh, under the auspices of the Carnegie Institute of Technology, to exchange ideas on the higher utilization of coal and to focus public attention on this subject.

To summarize: In the combustion of coal for the production of power, further large gains in efficiency are not anticipated except through the use of extreme high pressures; the centralization of power production continues at a fast pace with larger and larger units intercombined across the face of the country; high utilization is being attained through the use of gas and coke, both in the houses and in industry, and by electrification of small and large industrial units and railroads. The coal problem of this country is one of utilization in so far as the country at large is concerned.

C. E. LESHER

Progress in Hydraulics

Contributed by the Hydraulic Division

Executive Committee: Ely C. Hutchinson, *Chairman*, H. L. Doolittle, *Secretary*, R. L. Thomas, W. M. White, and H. B. Taylor

MUCH progress in hydraulics both technically and mechanically has been made in recent years, and since for the most part those developments which are representative of the greatest strides require several years for completion, it is difficult to give, in any one annual progress report, a precise statement of what may have happened that particular year. For several years past the art of hydraulic engineering has been undergoing a distinct evolution. From the building by "cut-and-try" methods in which designs were developed empirically in the pattern shop by the aid of a brilliant imagination, we have advanced into the era of technical understanding supported by scientific experimentation.

During the past few years large hydraulic-turbine installations have changed from the horizontal multiple-runner design to the vertical single-runner type. The press of economy has brought into commercial use the high-speed Francis-type turbine which has made it possible to develop power projects previously too expensive for competition with steam-generated power. High-speed propeller-type turbines, mostly for vertical settings, have made it possible to economically develop hydraulic-power projects at much lower heads and for larger water quantities. Installation of these propeller-type units for heads ranging from 8 ft. to 60 ft. is an accomplished fact and a practical success. Francis-type turbines are in successful operation in this country under heads as high as 930 ft. Broadly speaking, it may be stated as an indication of progress that hydraulic turbines are performing successfully under all heads up to 1000 ft. and for outputs up to 80,000 hp. per unit.

Pelton wheels have also advanced materially. Largely because there are fewer of them used, they have not kept pace with the hydraulic turbines in their rate of development. They have, however, reached a very high state of perfection and have been the means for the development of numerous ideas which have been adopted into turbine construction as well. Impulse wheels of the Pelton type are being built for all ranges of head and up to capacities of 56,000 hp. in individual units.

WATER CONTROL

Many improvements have been made in the mechanical means for control of the water supply to the prime movers. Head works in dams are being fitted with improved types of slide gates, Stoney roller gates, and gates of the caterpillar type. Tainter gates, roller dams, and the like continue to meet many of the requirements. In one case a bank of vertical-spindled rectangular butterfly valves placed end to end has been installed. The regulation of stream flow and water storage is, however, being largely cared for by the installation of needle-type discharge regulators which are generally placed downstream of the dam. Constructions of this kind have reached a high state of perfection. They are both manually and power operated, and are remotely controlled with great precision. This type of valve may be continuously operated in a partially opened position if required.

PENSTOCKS

Penstock construction is still of the riveted type for the lower pressures and large sizes. For the higher pressures such as encountered with impulse-wheel installation, the plain hammer-forged and welded pipe is being superseded by seamless forged and machined tubes. These are being made at the present time with a large diameter of 66 in. and thickness of $2^1/_2$ in. and a small diameter of 34 in. with a thickness of 3 in. These figures refer to the present penstock construction of the Southern California Edison Co. where two 56,000-hp. impulse wheels are being put in. Hammer-welded pipe with steel bands is being used for the lesser pressures, which are still too great for riveted construction.

The penstock elbows are made from solid ring forgings, machined inside and out, with subtended angles small enough to eliminate the necessity of attempting any curvature of the penstock axis within the elbow. Large bends are made by using several of the elbows together.

For flow lines and conduits, riveted steel, lock-bar, and electric-arc-welded pipes are used, and where conditions permit, wood-stave pipe lines are used.

AUTOMATIC PLANTS

Great progress has been made in automatic plants. These are being installed in increasing numbers and of increasing size, using either hydraulic turbines or impulse wheels. The mechanical detail involved in the successful and safe operation of these plants is being perfected continually, and the progress is extremely rapid. Automatic protective devices have been made very reliable. Plants with automatic or semi-automatic control have been installed up to capacities as great as 28,500 hp. per unit, as in the case of the Wallenpaupack installation of the Pennsylvania Power & Light Company.

Coming now to a consideration of the details of turbine and impulse design, a summary of the outstanding features will be of interest.

TURBINES

Plate-steel turbine casings are being effectively used for moderate heads.

The effect of draft head upon turbine design is being carefully studied, and in this connection the Hydraulic Power Committee of the National Electric Light Association has collected very valuable information dealing with the pitting of turbine runners and vibration of units during operation. Operating data have been secured from numerous power companies and are furnishing the basis for exhaustive hydraulic investigation. A much better understanding of the effect of draft head is resulting and several important developments in draft-tube construction are being carefully investigated, both theoretically and through experimental research. Ejector draft tubes for turbines have been greatly improved in design and efficiency.

Rubber bearings for vertical turbines are being used successfully, and the indications point to a considerable increase in life as compared with the hitherto almost universally used lignum vitae. It is still somewhat early to draw definite conclusions, yet it is significant that at the Holtwood Plant of the Pennsylvania Water & Power Company, an 8-in. experimental rubber bearing has been operating on a 1000-hp. vertical exciter turbine for twenty-two months with no appreciable wear. A 24-in. rubber bearing has been installed on a 16,500-hp. unit for ten months with equally good results. Rubber bearings are being installed experimentally at the Cheat Haven Plant of the West Penn Power Company, and experiments are being considered by the Susquehanna Power Company in connection with their new Conowingo development which will consist of seven 54,000-hp. units.

Rubber seal rings for turbines are still in the experimental state and their design is rapidly being perfected. Early construction, while successful in reducing water leakage and increasing power output, was attended with mechanical difficulties and an exact knowledge of the action of the rubber under the conditions. This knowledge is being gained by experimental research and by careful watching of existing rubber-seal-ring installations, several sets of which have been in successful operation for more than a year in this country and Mexico.

IMPULSE WHEELS

The accepted construction in practically all high-head, large-size Pelton wheels is the double-overhung, single-nozzle design in which the rotating element consists of the shaft, in the center of which the electrical generator is mounted and on either end of which a water-wheel runner is secured. The shaft rests in two bearings placed one on either side of the generator rotor, the water-wheel runners being overhung beyond.

The size of individual units in Pelton-wheel construction is rapidly growing. It is but eighteen months ago that the first units of 40,000-hp. capacity were built for installation in Brazil, and within less than a year following, units of 56,000 hp. were being built. Studies of units of considerably larger size than this have been made, and await only proper economic conditions for their building.

For the most part the designs all provide for water economy, using a power nozzle and securing the necessary relief and safety to the penstock during periods of speed regulation through auxiliary relief nozzles which are directly connected to the power nozzles so that movement of the former is accompanied by a corresponding inverse action of the relief nozzle.

Probably the most important progress in impulse-wheel design is in the improvement of the water distribution from penstock to wheels so that the water may be permitted to follow its natural direction of flow with the least possible interference and eddy disturbance.

GOVERNORS AND OIL SETS

The progress made in the design of governors and pressure oil sets for their operation has been very marked. This has come about very considerably through the requirements for regulating and operating automatically and remotely controlled plants. The large size of units has also made demands upon the governing apparatus which could only be met by increased sensitiveness and refinements of design. The same holds good of oil-pressure sets.

Practically all governors for important installations have as a part of their standard equipment switchboard-operated means for synchronizing and limiting the load. In addition indicating instruments are provided on the switchboard to show the exact positions of the turbine gates and the load-limiting device. The governors are fitted with safety appliances through which the entire unit may be shut down in case of difficulty with either the electrical or hydraulic apparatus. In addition to the usual mechanical tachometer provided on the governors electrical indication of the speed of the unit is carried directly to the switchboard for the information of the operator.

The governor drives are by belt, electric motor, and positive gear connection.

The tendency is to regulate the operation of pressure-oil sets through oil volume or level in the pressure-accumulating tanks rather than by oil pressure, as it gives more reliable results.

With the increasing size of hydraulic-power units individual pressure-oil sets are largely being used in preference to the duplicate central systems used previously.

VALVES

Progress in high-pressure gate-valve construction has reverted to the follower-ring design used a number of years ago but discontinued as being an unnecessary refinement. In this construction a ring is attached to the lower part of the main shut-off disk so that upon opening, the disk moves out of the line of flow and the follower ring is drawn into place, thus providing a continuous passage of smooth bore through the gate-valve body and also protecting the stationary valve seat against abrasion. This construction is of special benefit under the increasingly higher heads used in impulse-wheel plants but is not so necessary with moderate heads.

Butterfly valves are being used under the lower pressures where they are particularly adapted. Their design has been improved to the point where leakage has been reduced to a minimum, and they are serving very well as emergency shutdown valves at the upper ends of penstocks or in flow lines. In low-head installations they are also used as main stop valves. An interesting example in this respect is the Conowingo Plant of the Susquehanna Power

Company, in which seven butterfly valves 27 ft. in diameter are being installed as main shut-off gates adjacent to the turbines.

NEEDLE-TYPE JOHNSON VALVES—PUMPS

Needle-type Johnson valves are of improved design and are being installed for water controls at turbines and as regulating valves in dams. Their control has been simplified and research is proceeding to make them adaptable to an increased number of uses.

Recent progress in pump design has been very marked. In this class of machinery rubber bearings for use in pumps handling sandy and dirty water have greatly reduced the time out of service and increased the life of shafts and bearings. Pumps handling sandy or dirty liquids are being lined with rubber throughout. In the field of low-head, large-volume pumping the Moody spiral pump is filling an important need. These pumps are being used for handling water in great quantity under heads as low as $4\frac{1}{2}$ ft., and they are also being used for circulating condensing water in large steam plants.

In the West the gradually lowering of the water tables in the irrigation districts is resulting in the use of deep-well turbine pumps; the design of these is largely in the evolutionary stage but improvement is radly progressing.

CONCLUSION

In this report no attempt has been made to discuss the economic trend of hydraulic power nor to report individual installations. There is a marked revival of interest in steam power generation at the present time. This seemingly is a part of the economic cycle. There has been an undoubted popularity of hydroelectric plants for some time. This has resulted in the development of such hydraulic-power projects as have been economically possible. Apparently the development is reaching a point where steam plants of improved design are able to compete with water power at the existing development costs. There is also a desire of the public-utility companies to maintain a proper balance between hydro and steam power to assure continuity of service. The swing of the pendulum is therefore toward steam development.

There are, of course, many hydraulic-power projects not falling into this classification and these will be built as the power demand warrants. There are other projects in which the conditions or circumstances surrounding the license or grant of water rights will be a sufficient reason to require development. There is also the unmistakable influence of the desire to develop and conserve our natural resources rather than to use steam power where unused water power is available. It is consequently felt that there will continue to be plenty of incentive among the membership of the Hydraulic Division and those interested in its progress, to warrant their active interest and attention.

ELY C. HUTCHINSON, *Chairman*

Progress in Steam-Power Engineering

Contributed by the Power Division

Executive Committee: H. B. Reynolds, *Chairman*, John A. Hunter, *Secretary*, Frank S. Clark, Vern E. Alden, and F. M. Gibson

THE year 1926 has not witnessed any let-up in central-station development. As far as size is concerned, the most interesting development is the announcement that a power station with an ultimate capacity of 1,000,000 kw. is to be built on the shores of Lake Michigan. This is two or three times as large as the largest power station operating at the present time, and is equal to the combined generating capacity in the Chicago, Illinois–Indiana industrial district. The first unit to be installed in this station will have a capacity of 208,000 kw. The year 1926 has witnessed the initial operation of a large number of modern stations.

There has been no radical reduction in the fuel consumption per kilowatt during the past year. A number of stations are operating on an equivalent of 1 lb. of high-grade coal per kw-hr., while one station expects to operate on a consumption of about 0.9 lb. of high-grade coal after all of its equipment is in service.

Now that the coal consumption has been reduced so that the coal cost is only about one-third of the cost of power up to the bus bar, concentrated efforts are being made in some quarters to reduce the first cost of the power station, which is now responsible for about two-thirds of the power cost.

BOILER ROOM

Coming to the details of the boiler-room equipment, the outstanding development during the year is the introduction of the Wood type of boiler known as the "steam generator" into this country. This boiler consists of a furnace with the evaporating surface of the boiler distributed over all six sides. On the four sides and top the heating surface consists of a single row of tubes with the space between them filled by means of fins welded to the tubes and forming an extended heating surface. At the bottom of the furnace is a bank of bare tubes about four rows deep. This type of furnace is not adaptable to stoker firing, but is designed for pulverized-coal burning. The burners for feeding the pulverized coal are located in the upper part of the furnace and in the corners. The axes of the burners are at a slight angle with the horizontal and point a little to one side of the center of the furnace so that the flame and gases are given a whirling motion, similar to that which exists in the well-type furnace. After a large portion of the heat has been absorbed by radiation, the hot gases pass down through the bank of tubes at the bottom of the furnace and then up, first through a superheater, and then through an air heater. The advantages claimed for this type of boiler and furnace are that furnace brickwork is almost entirely eliminated and that the space required is less than that required by the standard form of boiler.

The use of water-cooled furnace walls, of which there are now several types, has extended very rapidly during the past year. One type consists of bare tubes allowing the brickwork to be exposed between the tubes. Another type is the fin type of tube which entirely covers the brickwork and presents an all-metal water-cooled surface to the furnace. Still another type employs cast-iron blocks which are bolted to water-cooled tubes. The faces of the blocks are covered with a thin layer of refractory. Two other types of water-cooled furnaces employ water-cooled tubes which are protected by cast-iron blocks. In one type the blocks are fitted on the tubes with a close fit, while in the other type they are cast on the tubes.

The use of water-cooled walls has permitted boiler ratings to be increased to a marked degree, and at the same time has very much reduced the cost of brickwork maintenance. In pulverized-coal installations the use of water-cooled walls has permitted a reduction in furnace volume in some cases.

The year 1926 has witnessed a number of installations of radiant-heat superheaters. There have been a number of superheaters of this type installed in connection with water-cooled walls where the superheater is placed between and to the rear of the water-wall tubes. This type of installation retains the advantages of the radiant-heat type, and at the same time the superheater is somewhat protected by the water tubes and so is not subjected to such severe punishment.

The principal cause of the failures of the tubes in the interdeck and radiant-heat type of superheaters has been the accumulation of solids in the tubes. These solids are carried over from the boiler by the moisture in the steam. This has led to the development of a number of steam purifiers, which take the place of the usual dry pipe in the boilers.

A great many installations of air heaters have been made during the past year. The use of water-cooled furnace walls has no doubt

not only simplified the use of air heaters, but has also made their use desirable in cases where water wall cooling has been applied to a great extent. Without water-cooled walls there has been some question as to whether or not the use of air heaters has increased brickwork troubles due to possible higher furnace temperatures.

On the other hand, it has been felt in some quarters that the use of water-cooled walls chills the furnace gases to a point which retards combustion, and that the application of air heaters tends to offset this effect by maintaining a higher furnace temperature.

There have been further developments in the underfeed stoker during the past few months, among which is the extended application of the hydraulic drive in place of the mechanical drive and the application of air zones under the stoker. The use of separately controlled air zones for the forced-draft air supply has made it possible to maintain high efficiency over a wide range of load. There has also been a further increase in the length of stokers. When air heaters were first introduced, stoker trouble was anticipated due to the lessened cooling effect of the air. However, the stoker manufacturers seem to be meeting this new condition in a satisfactory manner.

Pulverized coal for central stations has become standard practice, as is evidenced by the great number of new power stations which have adopted this method of fuel burning. The development of water-cooled furnace walls has aided the satisfactory application of pulverized coal in that brickwork trouble, which was one of the drawbacks of burning pulverized coal with the maximum efficiency, has been very much reduced by their use.

Although the central preparation system is the one most favored for large installations, the unit system is being given serious consideration. One very interesting and recent installation of pulverized coal is in an old station where the boilers were set fairly low and space was very much limited. However, by lowering the bottom of the furnace below the firing floor and using the refractory-protected type of water-cooled furnace wall with unit pulverizers, a very satisfactory installation was obtained.

The first low-temperature distillation plant has been installed in this country at a power station burning pulverized coal. The plant will treat about 200 tons of coal a day.

Two-stage combustion has been suggested again, whereby the furnace of a boiler is divided into two parts. Part of the fuel would be burned in the first part with a high excess of air. The products of combustion would then pass over a part of the boiler heating surface and would thus have their temperatures reduced, and then into the second combustion chamber, into which the remainder of the fuel would be fed. The final products of combustion would then be very low in excess air, and at the same time the furnace temperatures would not be excessive at any time.

The electrostatic method of precipitating stack dust has been improved and extended in a plant burning pulverized coal. A number of new mechanical dust and cinder catchers have been recently placed on the market.

The use of automatic control has been extended to take care of almost every operation in the boiler room, and in a number of cases where full automatic control has been installed it has been possible to operate at an efficiency very near that obtainable under test conditions.

Before leaving the boiler-room side of the power station, mention should be made of an investigation of the causes of the embrittlement of boiler plate, the results of which have been published during the past year. This subject is of very great importance to boiler users. However, there has been a great divergence of opinion as to the cause of this trouble. Briefly, the conclusions arrived at as a result of this investigation are that embrittlement of boiler plate is caused by a combination of stress in the metal and chemical attack. This emphasizes the importance of careful fitting of boiler parts so as to reduce abnormal stresses to a minimum.

An extensive research program is now being carried out in this country on high-pressure piping, valves, etc.

Turbine Room

Coming to the turbine room, the outstanding development of the year has been a very radical increase in the size of turbine units. As mentioned at the beginning of this report, there is one unit on order which is to have a capacity of 208,000 kw. This machine will be of the compound, triple-cylinder type. That is, it will have a high-pressure element of 76,000 kw. capacity, taking steam at 600 lb. pressure and 730 deg. fahr. Before passing to the two low-pressure elements the steam will be reheated to a temperature of 500 deg. by means of live-steam reheaters. After being reheated, the steam will pass to the two low-pressure elements, each having a capacity of 66,000 kw. A 4000-kw. house generator will be attached to each low-pressure element. In the cross-compound type of turbine the record for size is a 160,000 kw. unit recently ordered. Two units of the tandem-compound type have been ordered which will have a capacity of 105,000 kw. each at unity power factor. These turbines will drive the largest generators ever built for any type of steam turbine. The record for size of the single-cylinder type of turbine has also been broken within the last few months, as an order has recently been placed for a 63,000-kw. unit. In addition to these machines which break the record for size in their respective classes, orders have been placed during the last few months for a number of other machines of unusual capacity. In fact, the size of turbine units has increased so rapidly within the last year that it would not be at all surprising if new records were established before this report is published.

Condenser capacity has of course kept pace with the size of the turbine units. There has been further application of the vertical type of condenser. The single-pass condenser has also gained favor during the past year. An interesting development is the dividing up of the condenser into sections by making the tube-supporting plates tight and then connecting an independent air-removal nozzle to each section. The advantage of this arrangement is that a different pressure drop is maintained in each section so that a complete penetration is produced. Some advance has also been made in obtaining a more rational arrangement of tubes, resulting in tapered steam lanes from the top to the bottom of the condenser. In a few installations where the condenser is bolted directly to the turbine, use has been made of a lever and counterweight system for supporting the condenser.

A three-stage air ejector has been put on the market which will result in a further reduction in the amount of steam used for air removal from condensers.

For serving a 35,000-kw. turbine, a jet condenser of the single-unit type has been installed recently which establishes a new record for size in this class of equipment.

Power-Station Heat Cycles

The year 1926 saw the first 1200-lb.-pressure system placed in operation, which is being followed closely by an installation which uses a boiler pressure of 1390 lb. per sq. in. Both of these installations are similar in that the high-pressure steam passes to a high-pressure turbine, from which it is exhausted into the station steam header after being reheated. With the exception of these two super-pressure installations—which apply to only a part of the stations—the maximum steam pressure seriously contemplated at the present time seems to be around 600 lb., while the maximum temperature is about 750 deg. fahr. There is a tendency to favor an increase in temperature rather than an increase in pressure.

The use of two to four bleeder points on the main turbine for feed-water heating seems to be the usual practice, while three-point bleeding seems to be the most favored. In one large station under construction at present, small turbines are being used for driving most of the auxiliaries. However, the main turbines will be bled in order to complete the heat cycle.

As mentioned before in this report, a large turbine is being built which will employ reheating between elements by means of live steam. It is interesting to note that although this method of reheating was applied to engines a great many years ago, this is its first application to turbine units.

The mercury plant which was installed a few years ago has been changed to some extent. The mercury pressure has been raised to 48 lb., while a three-stage turbine has been installed.

Industrial Power

The progress of industrial power in the past year has been greater than that in recent years due to an increased concern on the part of the owners and managers of industries in the cost of their power.

This increased interest has caused better engineering service to be employed in the investigation of costs, load demands, and operating conditions, resulting in more liberal financing and more intelligent consideration of the subject.

In the industries which have little or no heating- or process-steam demands, many plants have resorted to purchased power and installed more efficient heating plants, while other plants of this type have shown some progress, principally in the way of better condenser equipment, better operating conditions, and better personnel.

The greatest progress has been in the industries which have a sufficient demand for exhaust steam to warrant making their own power. The outstanding feature is the increased use of higher steam pressures. Most of these applications have been for the purpose of securing additional power without producing more exhaust steam, and have included a high-pressure boiler, generally of 400 lb. pressure, supplying steam to a high-back-pressure turbine which exhausts into the main steam line of an existing boiler house with a pressure of about 150 lb. One installation will use steam at about 600 lb. Several plants have accomplished the same purpose or have relieved overloaded low-pressure heating systems by installing a bleeder-type turbine without increasing the initial steam pressure. By bleeding a large proportion of the steam into a process-steam system and exhausting the rest of the steam into the low-pressure heating system, additional power is secured without additional increase in exhaust steam, or a condition of an excess of exhaust steam is corrected. The heating of feedwater with steam bled from turbines has been used in only a few instances in industries having a large process demand for hot water and a supply of raw water requiring but little chemical treatment. There have been few installations of air preheaters or accumulators.

In certain sections there has been a decided increase in the number of pulverized-coal installations. In a number of cases, due principally to the unit system, the cost of a pulverized-coal system has been cheaper than that of a stoker installation. Stoker installations have shown a trend toward better furnace design and larger grate areas. There has also been an increased use of automatic stokers on smaller sizes of boilers, in some instances on boilers of but 100 hp.

One encouraging feature of progress has been the increase in reliable records of continuous operation. Not only the larger plants but several small plants have shown very high efficiencies. The lack of records in the great majority of industrial power plants has been the chief cause of the lack of interest on the part of owners and of the excessive cost of industrial power. The present trend toward reliable power records is therefore most encouraging.

H. B. REYNOLDS, *Chairman*

Progress in Oil- and Gas-Power Engineering

Contributed by the Oil and Gas Power Division

Executive Committee: Edgar J. Kates, *Chairman*, L. H. Morrison, *Secretary*, C. M. Manly, Geo. D. Pogue, and John W. Morton

IN MILITARY parlance, the activities during 1926 of engineers and manufacturers interested in the oil-engine industry have been directed toward a consolidation of its earned positions. The most important progress to be noted is that evidenced by the extension of the maximum unit capacity, the extension of the maximum r.p.m., and the reduction in weight of small-powered units. On the one hand is found the 15,000-hp. Blohm & Voss Diesel installed this year in the Hamburg municipal plant, and on the other are the light-weight high-speed units such as the Foos and the Bessemer in this country, and the Beardmore, Benz, and M.A.N. abroad.

The Hamburg engine is worthy of especial mention since it is the largest internal-combustion engine ever constructed and is of a capacity sufficient to fill the requirements of any industrial or central-station plant, and should set at rest for all time the current belief that the oil engine is by necessity a small-powered machine. In commenting upon the year's progress in Germany in Diesel building, Dr. Naegel writes to the Oil and Gas Power Division:

The Hamburg engine of 15,000 b. hp. was built according to the patents and with the coöperation of the M.A.N. by the firm of Blohm & Voss. It has nine double-acting, two-cycle cylinders of 860 mm. (33.86 in.) bore and 1500 mm. (59.05 in.) stroke, and normally runs at 94 r.p.m. The engine has an overall length to the coupling of 23.4 meters (76 ft. 9 in.) by 4.3 meters (44 ft.) width. The height from the crankshaft center to the upper end of the valve spindles of the upper cylinder heads amounts to about 10 meters, or 35 ft. The engine is coupled to a 3-phase, 50-cycle, 6000-volt alternating-current generator which was furnished by the Siemens-Schuckert Works.

The installation was started early in the summer of 1926 and subjected to acceptance tests from the first until Sept. 3. The following results were obtained:

1 The time required for starting from complete rest until taking up the full delivery of current into the line could be reduced to 3 minutes.

2 Upon being suddenly unloaded from full load to idling, the speed momentarily increased by 14.5 per cent, to be diminished almost immediately, and after a total lapse of 32 seconds to settle down to the equilibrium condition at no load.

3 The excess pressure of the scavenging air assumes a value between 1210 and 1230 mm. water column. At the normal load of 14,640 b.hp. the power input to the scavenging blower amounts to 728 hp. According to this, the mechanical efficiency of the Diesel engine, disregarding the blower horsepower, amounts to 0.84, and with its inclusion, to 0.80.

4 The consumption of fuel—not including the electrically driven scavenging blowers—was determined according to the following table.

Load	Effective output, b. hp.	Indicated output, b.hp.	Fuel consumption per b.hp-hr., lb.
4/4	14,640	17,450	0.371
3/4	11,280	14,120	0.363
2/4	7,740	10,460	0.366
1/4	3,780	6,400	0.457

5 The consumption of lubricating oil for the entire Diesel engine, which was lavishly lubricated as a safety measure, amounted to only 0.0015 lb. per b.hp-hr. at full load.

Some years back, in reviewing the progress of the Diesel engine in the marine field, a well-known publication registered the opinion that one of the great contributions made by that branch to the progress of the profession as a whole lay in the tremendous competitive stimulus given to steam marine engineering by the success of the Diesel.

Recent developments in Great Britain confirm this opinion. There much of the discussion in recent meetings of engineering bodies has centered around the application of high-pressure, high-superheat steam to marine propulsion. But from the recent paper of Sir John Biles, read at the summer meeting of the Institution of Naval Architects, held in Antwerp, Belgium, on June 22, 1926, we now venture to predict that the chief value to the progress of marine engineering in the introduction of high-pressure steam will be the stimulus to the Diesel engineer, who will now be forced to standardize the marine Diesel power plant, and cut down first costs for the shipowner.

At the present time, both in new construction and in operation, the Diesel engine has much the better position in the argument.

There is not a motorship among all the thousands of idle vessels laid up in British and continental ports.

Every large shipowner who has given the Diesel engine a good trial has been converted himself and is rapidly converting his fleet. A very large proportion of all tonnage on order is for Diesel propulsion, and the majority of the first-class ocean-going passenger liners now building are to be Diesel-driven.

Double-acting two- or four-cycle units of 8000 to 10,000 hp. are now almost standard equipment for large European passenger vessels. One of the latest motorships is the Italian liner *Saturnia*. This vessel, of 35,000 tons displacement, has been launched and is now being fitted with two 12,000-hp. Burmeister & Wain double-

acting four-cycle engines. With the nine auxiliary engines the total Diesel capacity in this one vessel will be 33,000 hp. Another outstanding vessel under construction is the *Oceania*, which will have four B. & W. 8000-hp. engines for the propeller drive, making the total capacity, including auxiliaries, about 45,000 hp. With such units as these, apparently the Diesel can be built in any needed size. It is doubtful, however, if the faster express boats and naval vessels can be sufficiently engined within the space available. Since 90 per cent of the ocean business is handled by ships of under 20,000 tons displacement, present Diesel sizes are ample.

In Germany a tendency in modern motorships seems to be toward high-speed, light-weight engines, geared to the propeller shaft through mechanical or hydraulic transmission or through a combination of both systems. Blohm & Voss of Hamburg use mechanical gearing with the pinion mounted on a hollow spindle driven by the shaft of the engine through a large flange, the engine shaft being extended inside the hollow spindle. This arrangement gives sufficient flexibility to cushion maneuvering and propeller shock, and adds greatly to the flexibility and life of single-reduction gearing.

The Vulcan Works at Stettin have worked out an excellent arrangement of Föttinger hydraulic clutches and mechanical single-reduction gearing that is giving excellent service on several installations. This gear reverses with the hydraulic clutch and gives about 60 per cent power in reverse. It has a transmission efficiency of about 96 per cent.

In Great Britain the tendency toward double-acting Diesel engines is even more marked than on the continent or in the U. S. A. There double-acting units are being installed in several fast single-screw freighters for far eastern routes.

The superior overall economy of higher-speed freighters with their high annual earning power is a happy result of this arrangement. Nearly every large British ship-operating firm is financially interested in one or more shipbuilding plants, and seems willing to experiment with promising new types of Diesel engines.

In America the progress of the Shipping Board program of conversion will give an opportunity to study the comparative merits of two- and four-cycle, single- and double-acting engines; by spring, 1927, we should have quite a demonstration fleet of motorships.

The first of the Shipping Board's engines to be tested were the Worthington two-cycle, double-acting units. An extensive report on the test appeared in the engineering journals last spring.

These were followed in rapid succession by the McIntosh & Seymour single- and double-acting, four-cycle, 2700-hp. Diesels, and by the 3000-hp. Busch-Sulzer single-acting, two-cycle units. These latter units are rated at 90 r.p.m. and for stationary service would be rated at 4000 hp. at 105 r.p.m. During a 30-day full-load test the first of these two-cycle units averaged 0.413 lb. of oil per b.hp., the average thermal efficiency based on indicated horsepower being 44½ per cent.

Other builders who are completing Shipping Board engines are the New London Ship & Engine Co. and the Hooven-Owens-Rentschler Co. Of smaller capacities are such installations as the 1500-H-O-R double-acting engine for a Standard Oil Co. tanker.

The real volume of marine Diesels has been in capacities below 500 hp. As Frantz Schultz, Director of the Deutz Co., of Germany, writes:

> Shipping circles have in the past year shown a growing interest for motor drive and particularly for the purchase of Diesel engines in sizes from 20 to 500 hp. Owing to the acute stagnation of deep-sea shipping, inland water transportation has an especially large share in this tendency. On all German rivers a rapidly increasing number of motorships may be observed today. Diesel tugs of moderate capacity are being used on all large streams, in the canals, and in harbors. In sizes above 100 hp. a preference for the four-cycle engine is to be observed here.

In the United States the number of marine engines under 500 hp. installed in vesssels during the year is astonishingly large. These include both air- and solid-injection, but the latter includes about 80 per cent of the total, although the 68 Winton 180-hp. engines for the Coast Guard are all of the air-injection type. Even though many two-cycle, solid-injection engines have been installed, the four-cycle has the preference at present.

European shipping interests have not adopted the Diesel-electric drive as extensively as have the American. There are some services where this drive is ideal, and, of course, others where it is not a practicable proposition.

It is making a strong bid for favor as a drive for short-trip ferries, and for harbor craft of many types, particularly shallow-draft tankers. Diesel-electric is coming into favor both on the Pacific and the Atlantic coasts for dredges, sea-going tugs, and for small special coasters.

TABLE 1 MACHINERY OF THE WORLD'S MERCANTILE FLEET

Type of vessel	July, 1926 Gross tons	July, 1925 Gross tons	Increase or decrease for the year, gross tons
Reciprocating-steam-engined vessels	50,040,978	50,566,029	525,051 decrease
Turbine ships	9,137,675	9,100,274	37,401 increase
Motorships	3,493,284	2,714,073	779,211 increase

TABLE 2 NEW TONNAGE CLASSED BY LLOYD'S REGISTER

Period	Total steam and motor tonnage, gross tons	Type of Engine: Steam reciprocating, gross tons	Type of Engine: Steam turbines, gross tons	Type of Engine: Motors, gross tons
1918–1919	3,760,806	2,633,570	1,051,302	75,934
1919–1920	4,186,882	2,821,031	1,286,046	79,805
1920–1921	3,229,188	2,373,067	754,513	101,608
1921–1922	2,517,513	1,420,924	870,037	226,552
1922–1923	1,610,624	842,358	603,037	165,229
1923–1924	874,651	610,851	99,464	164,336
1924–1925	1,311,277	894,807	114,009	302,461
1925–1926	1,324,789	575,984	146,354	602,451

TABLE 3 MARINE ENGINES UNDER CONSTRUCTION IN JUNE, 1926

Steam Engines: Reciprocating No.	Steam Engines: Reciprocating I.hp.	Steam Engines: Turbines No.	Steam Engines: Turbines I.hp.	Oil Engines No.	Oil Engines I.hp.	Total No.	Total I.hp.
280	432,968	39	362,415	295	733,496	614	1,528,879

TABLE 4 DIMENSIONS AND POWERS OF LARGE ENGINES NOW BUILDING

Type	Cylinder Dimensions: Bore, Mm.	Cylinder Dimensions: Stroke, Mm.	Speed, R.p.m.	Cylinder Power: I.hp.	Cylinder Power: B.hp.
Doxford opposed-piston	680	1360	90–100	1375–1500	1250–1350
B. & W. 4-cycle D. A.	840	1500	125	1500	1250
M.A.N. 2-cycle D. A.	700	1200	120–125	1300–1460	1040–1166
Busch-Sulzer 2-cycle S. A.	900	1600	86	1260	1000

Taken as a whole, the marine Diesel-engine situation is quite hopeful and motorship registration is gaining rapidly on that of steamers as shown in the tables. Every projected ship is an active Diesel-engine prospect.

Motorships in active service are accumulating records of performance which make unanswerable arguments. The most conservative shipowners in the world have been almost completely won over.

If the marine Diesel designer, manufacturer, shipbuilder, and engineers can now get together to produce a standard marine installation which can be built on a manufacturing basis for volume production so that Diesel installation costs will approximate steam installation costs, the world's new merchant fleet will eventually be Dieselized.

STATIONARY ENGINES

The stationary power field has always absorbed the greatest percentage of oil engines. The same condition has existed in 1926. Units so installed ranged from 30 to 3750 hp. The average horsepower of such units has been below 300 hp. and solid-injection units of the two-cycle type predominate. The basic reason for this is that small steam installations are not efficient and cheap electric energy is obtainable only in large blocks.

There is, however, a marked interest in units of large outputs, and the average unit capacity sold by one builder was over 1600 hp., but one engine being under 1000 hp.

One of the main reasons for this tendency toward the use of larger engines is the fact that it is being generally realized now that this type of unit is practical in the larger sizes. Comparatively few years ago, when one thought of a Diesel engine he thought of a unit of but a few hundred horsepower. There are many instances, however, where several thousand horsepower is needed and where it would be out of the question to install, say, ten 400-hp. engines when two 2000-hp. engines could be secured. The increased cost of installation, the greater operating labor and maintenance required for ten small units, would be out of the question in comparison with this same amount of power being built into two units. It is true that the fuel economy of the larger

engine is not a great deal better than of an engine of the smaller size, but when it comes to the large plant, there are other factors which enter into this which makes the overall operating cost of the large plant considerably less than that of the small one. It would be absurd, however, to claim that the Diesel engine can take the place of the steam turbine in the very large plants. There is a limit to the size of the Diesel engine, which so far in this country has been about 4000 hp. per unit for stationary service.

Among the larger units ordered or installed during the year were the three 3750-hp. Nordberg engines for the Panama Canal, two 2250-hp. Diesels for Punta Gorda, Fla., and three other Nordbergs of the same capacity for the Commercial Mining & Royalty Co. of Miami, Okla. Other large engines included four 1150-hp. Busch-Sulzer two-cycle engines ordered for a Lake Michigan dredge, a 1000-hp. McIntosh & Seymour and a 1000-hp. De la Vergne Diesel for Lake Worth, Fla.

Builders have improved the design of the larger Diesel, but manufacturers of smaller units have introduced new designs or changes in details. The Winton Company has developed an 800-hp. air-injection Diesel with a bore of $16\frac{1}{2}$ in. and a stroke of 22 in. The pistons are made of Bu-Hite aluminum alloy and carry two steel rings cast in the alloy walls for hoop strength.

Fairbanks, Morse & Co. have developed a low-cycle solid-injection engine in 360-, 600-, and 720-hp. sizes. These units do not use crankcase compression but are provided with a separate double-acting reciprocating blower. The Fulton Iron Works Co. has adopted a one-piece frame in place of its former A-frame.

The McIntosh & Seymour Corp. has developed a small medium-speed four-cycle Diesel of 30 hp. per cylinder.

Oil-Locomotives

There is a tremendous interest in this country in the use of Diesel engines for railway service, the first equipments having been of small power for switching service. The smaller railway cars have been driven by gasoline engines with direct drive along the same lines as the regular motor truck. The larger ones are driven by gasoline engines with electric drive.

For railway equipment the transportation companies greatly desire to eliminate the electric drive if possible, also to reduce to a minimum the weight of the Diesel engine. This has stimulated investigation and design of the various methods of direct and hydraulic drive, but as from the nature of the case some form of transmission is necessary and from the nature of the service it must be very substantial, no form of mechanical or hydraulic drive has yet been put in operation which is enough lighter and cheaper than electric drive to compensate for some of the disadvantages which go with this type of equipment.

There are two ways to get down to minimum weight for this railway equipment. One is to increase ratings and reduce weight to extreme limits; the other is to base the ratings on what experience has shown will give satisfactory service, and provide such weight as will give satisfactory operation. Both of these kinds of equipment will go through a process of evolution. On the one of the extremely high rating the ratings will be reduced and the weights will be increased, and on the other the weights of the details will be reduced, so that eventually both will reach about the same point. However, in one case the equipment will have given satisfactory service and have stimulated development, and in the other will have caused continual trouble and retarded growth.

Ingersoll-Rand with a solid-injection, 600-r.p.m., four-cycle Diesel, and McIntosh & Seymour with a V-type, four-cycle, air-injection unit, have done much real development work. The Bessemer Gas Engine Co. is also developing an 800-hp. unit for the Pennsylvania R. R. With the number of locomotives now in service or on order, even the most pessimistic must concede that the oil-engine locomotive is an actuality. While all have so far adopted the motor-generator drive, much attention is being given to mechanical and hydraulic transmissions. While all the locomotives so far built have been for switching purposes, the New York Central has purchased an 800-hp. unit for main-line passenger service.

The possibility of high-speed Diesels replacing gasoline engines for such purposes as industrial locomotives, power shovels, etc. has always been attractive to designers. During the year three firms in the United States have developed such an engine, of which two, the Foos Gas Engine Co. and The Bessemer Gas Engine Co., have arrived at a stage where installations are being made. These high-speed units, running up to 900 r.p.m., are all of the solid-injection type as the compressor presents difficult problems. The Foos Co. has installed its engine on an industrial locomotive and upon power shovels. The added cost of the complete shovel over the gasoline-driven machine is about $3000, but this is returned in less than two years by the fuel saving.

The engine has cylinders $8\frac{1}{2}$ in. bore by 11 in. stroke, and is rated at 5.5 hp. per cylinder per 100 r.p.m. One of the difficulties in handling an engine of this kind will be to determine in some cases the speed allowable, as the heavier the duty, the lower the speed must logically be; and 600 to 700 r.p.m. is considered a good working speed for what might be called an average duty for this kind of an engine. Nevertheless speeds of 900 r.p.m. are feasible when required.

As far as can be ascertained, all save one of the high-speed engines both here and abroad make use of a symmetrical cylinder without a separate combustion chamber or precombustion device. Apparently when the r.p.m. goes over a certain value the lag in gas flow from the separate combustion space is too great to maintain a proper cylinder pressure, although the Fairbanks-Morse 600-r.p.m., $7\frac{1}{2}$-hp.-per-cylinder engine uses the same cylinder-head design as in the slower-speed-type Y engine.

In certain circles the report of the Federal Fuel Commissioners has been interpreted as indicating that an oil supply will not exist after six years. The report does not bear out this contention, for the commission dealt with proven fields and did not attempt to estimate total resources. Inasmuch as the large production has always been from fields unknown ten years previous, there is every reason for assuming that the oil supply will last for some length of time. In 1914 the Government issued a somewhat similar pessimistic report which said exhaustion would occur in 1921. It should not be forgotten that shale offers a supply of oil for hundreds of years, and in the low-temperature carbonization of coal a further oil supply is seen.

Interest during the year has been aroused by developments in a powdered-fuel engine. The Department of Agriculture has experimented with grain dust, but the worthwhile investigation has taken place in Germany, where Rudolph Pawlikowski is operating a modified M.A.N. Diesel on powdered coal. However, only coal of a special character can be handled, which limits the use of such fuel. It is questionable if such an engine is the solution. As Dr. Lanster, director of the M.A.N. Co. and former co-worker with Dr. Diesel, stated in an interview, "The using of raw coal in steam plants will be abandoned in the future to make way for low-temperature carbonization and the recovery of by-products. To me, the engine problem will be solved by the use of the tar oil instead of the direct combustion of the raw coal within the engine cylinder."

Large Gas Engines

While the capacity of the first gas-engine units installed in steel mills in 1907 was only 2000 kw. per unit, there are now gas engines with a normal output of nearly twice this amount.

The tendency is for still larger units, which will very likely be rated above 6000 kw. with a maximum rating of 7000 kw., or 10,000 b.hp. This increase will be brought about by a combination of larger cylinder diameters, higher piston speeds, and greater m.e.p. in the cylinders. The general design and arrangement of these units will be the same as those of older machines of the twin-tandem, double-acting, four-cylinder type.

The old-type cylinders were either cast in one piece with an inner and outer wall forming the water jacket, or in two pieces with a separate jacket on the outside to facilitate molding and cleaning in the foundry. All cylinders, whether made of a steel casting or of cast iron, were fitted with a cast-iron liner for wear of the piston rings. The new-design cylinder will be a one-piece casting cored out in such a way so that the inner and outer walls will be free to expand or contract without setting up any stresses in the adjacent parts of the casting. The annular spaces between the walls and pockets will be closed watertight with flexible material.

The above arrangement will eliminate casting and expansion stresses, and will go far toward giving the cylinders long life

Cast-iron liners in the cylinder bore will be used as heretofore.

The methods employed up to this time consist of forcing water into the jackets of the engine parts either in series or parallel, and it has been noted that the parts to be cooled are always warmer at the top than at the bottom, resulting in uneven expansion and increased stress.

Diffusers are now fitted to the end of the incoming water line, creating high velocity and turbulence within the jackets and keeping an even temperature throughout.

Improvements in regulators and automatic relays have made the gas engine as sensitive to load variation as the steam turbine.

Changes in valves and mixing gear have eliminated the so-called "drowning" of gas engines when overloaded, and have increased the thermal efficiency by utilizing all available heat units in the gas.

Gas blowing engines continue to be by far the most economical type for supplying air to the blast furnace.

The blowers are being increased in size, so that a twin-tandem gas engine with duplex tubs will furnish 60,000 cu. ft. of air per minute, which is sufficient for a furnace of 800 tons capacity.

At the present time the most noteworthy large gas engine being built is a 4000-hp. unit by the Allis Chalmers Co.

The undersigned gratefully acknowledges the especial assistance of Edgar J. Kates and John Morton of the Division's Executive Committee, as well as that of the several engine builders.

L. H. MORRISON, *Secretary*

Progress in Machine-Shop Practice

Contributed by the Machine-Shop Practice Division

Executive Committee: W. F. Dixon, *Chairman*, W. J. Peets, *Secretary*, James H. Connolly, E. S. Patch, James W. Hook, and L. C. Morrow

IN DESCRIBING the progress made in machine-shop practice during the past year, consideration must be given to two groups of engineers—the equipment builders and the equipment users. The work of the builders of new and better equipment has been important, and any one interested has only to read the various trade journals to be convinced of the significant engineering advances made by this group of men. A considerable amount of the progress made in developing manufacturing methods and equipment, however, is due to the engineers employed by the users of shop equipment.

A careful analysis of the shop operations and equipment of many metal-working shops and factories will disclose that their standard machines are fitted with special attachments, jigs, fixtures, and tools designed by the users. In fact, many shops will be found where a very large percentage of the machine tools used are entirely special, having been built by the shops using them. Most of this progress is little advertised and therefore generally unknown, but its effect on industry is very great.

There are certain tendencies shown by most of the new machinery being turned out by the machine-tool builders. Motor drive has increased in popularity, and practically every machine-shop tool built today has motor drive—at least as optional equipment. In some cases motor drive is standard and countershaft drive special, while in others motor drive only is furnished. Motors are applied not only to the larger units, but equally to the smaller machines such as small drillers, tappers, etc. requiring fractional-horsepower motors. Motors are more and more being designed into machine tools rather than "tacked on" as an afterthought. Certain lathe makers, for instance, list three distinct types of drive, none of which can be readily changed to the other: first, the familiar countershaft-driven cone type; second, the counter- or line-shaft single-pulley type; third, the motor-driven type, with motor in leg. In some machines, motors are built directly on spindles, or geared directly to them, and several motors applied to one machine.

There is still plenty of room for improvement, however, in the details of some of these motor-driven machines. More attention could well be paid to wiring. Metal piping should be used wherever possible instead of BX and loom coverings, and where motors are placed on moving slides, great care should be taken to prevent chafing. This is particularly true where oil and cutting lubricants are present and a comparatively high voltage is used. Further, where motors and controls are at all complicated, a clear wiring diagram for the complete system should always accompany the machine.

Another tendency in machine-tool manufacture has been toward better bearings. Ball and roller bearings are being more and more employed. Having first been used successfully on intermediate shafts, their application is extending, and now they may be found on the main spindles of several precision machines.

An equally important improvement has been made in lubrication. Flood lubrication by pump or splash is the rule in the best grade of lathes, milling machines, drillers, etc.

Control is another important branch of development. New models of machine tools prove that considerable thought has been given to ease of control, and facility in chucking or feeding. Fast table movements on milling machines, treadle control of work heads on grinders, push-button control, pneumatic and hydraulic chucks and vises, automatic mechanical chucks, and the bringing together of all control handles within easy reach of the operator—all show this tendency.

Another growing tendency is shown by the increasing number of purely special machines being built. First, the builders of standard equipment are employing no little ingenuity in fitting their machines with attachments particularly adapted to do some one special job. Second, a great many purely special machines are being built. Examples of this are the multi-spindle drillers and multi-head millers built for the automobile trade. In some instances these machines, while entirely special, employ standard beds, heads and parts—which makes for great economy in their construction.

Hydraulic feeds have been utilized by several designers of new machinery. In some cases the power is supplied to the hydraulic cylinders in the machine by oil under pressure from an accurately controlled pump. Drilling- and milling-machine feeds, broaches, honing machines, and a variety of special machines have lately embodied this feature.

Quite a complete line of precision measuring apparatus has been placed on the market during the past year. Most of this apparatus utilizes optical multiplication of some sort. There is a growing use of precision measuring equipment in this country, and great strides have been made in adapting what was formerly laboratory equipment to the shop, and putting it to work there. Such equipment for shop use is available which makes possible measurements correct to $^1/_4$ of a ten-thousandth of an inch, or even closer.

The honing of bearings is gaining in favor, especially in the automobile factories, where cylinders are being honed on improved machines, and wristpins are lapped to close limits and a mirror finish by machinery.

Machinery for grinding gears has been improved, and the use of the ground gear is being extended.

At least two machines for the accurate boring of jigs have been perfected, and are filling a long-felt want.

Electric control has recently been applied to a milling machine for roughing out sheet-metal punches and dies. A templet is provided of the exact shape of the hole in the die, and the feed movements of the cutter are controlled from this templet by electricity.

An interesting process recently developed is chrome plating.

While still in an experimental state, this promises to become useful in certain lines.

The arc welding of stellite has provided a successful method of adding a hard, heat-resisting surface to steel, and this is now being applied to the ends of plug gages, to parts of machinery subject to wear, and to mechanisms subject to both high temperatures and wear, such as the parts of automatic furnaces and hardening machines.

At least three automatic station chucking machines have been perfected in the past year. One of these is a vertical machine of 6 in. capacity, fitted with automatic mechanical chucks, the other two being of the horizontal type, with air chucks.

Development is shown in the design of grinding machines, including the wide-wheel machines used for straight-in feed and with plenty of power.

Generally speaking, the year has been one of steady improvement in details rather than one of startling new inventions. There is a growing demand for machinery that conserves the strength and time of the operator, as well as for such apparatus as dust-suction systems, conveyors, automatic chucks, etc., which are quite as often installed to lighten the operators' work as to cut down costs. Whereas progress in any one direction has not been phenomenal or radical, there is hardly a machine on the market which has not been improved during the past year

W. F. DIXON, *Chairman*

Progress in Textile Mechanical Engineering

Contributed by the Textile Division

Executive Committee: James A. Campbell, *Chairman*, James W. Cox, Jr., *Vice-Chairman*, Chas. D. McEvoy, *Secretary*, Geo. H. Perkins, and E. H. Marble

IT IS A WELL-KNOWN fact that the textile industry holds first rank in number of wage earners, wages paid, and value added by manufacture among the sixteen major manufacturing groups. The depression of 1924 has held through 1925 and part of 1926. There is a more optimistic feeling, however, at present, and without doubt the industry is now on the upward trend. The consumption of raw materials has been increasing during the year, and many of the plants are now running full. The early part of 1926 found the silk industry running at capacity, but a depression was felt in the summer months. The worsted mills have been running on short time, and it is believed that one contributing factor is that our mills have a tendency to turn out a cheaper and lower grade of goods, and this, no doubt, allows an open field for foreign manufacturers of high-grade worsted and woolen goods.

DEVELOPMENTS IN THE TEXTILE INDUSTRY

The following figures from the Official Textile American Directory show the number of textile mills in the United States and the classes of work they are engaged in:

Cotton mills	2172
Woolen and worsted mills	1332
Dyeing, bleaching, finishing, and printing works	764
Knitting mills	2990
Silk mills	2026
Flax, linen, and jute mills	178

There are several miscellaneous mills which bring the total to 9800. These plants give employment to over 1,000,000 people.

The growth of the industry can be seen when we realize that it was first introduced into this country in 1800. At the present time the cotton spindles installed are about 22 per cent of the world's total. Fig. 1 shows the number of cotton spindles in the United States installed and active from 1905 to 1925.

It will be noted that the decline in active spindles has been steady since 1923. During March of the present year mill consumption of raw cotton broke all records in spite of the poor market for cotton goods. The Cotton Textile Institute recently formed should be of great benefit in correcting the above conditions. It is to be hoped that this Institute will also aid research in the industry. At the end of September there were approximately 20,000,000 spindles signed up, and this is 55 per cent of the installed spindles in the country.

The woolen and worsted manufacturers are forming a Wool Council to study problems in their industry, and no doubt benefits will accrue to the mills engaged in the manufacture of these goods if a careful survey is made. It has been stated recently that the steel and some of the other major manufacturing groups can operate at a profit when their plants are running at 75 per cent of capacity. The textile mills are unable to show profits when operating at 100 per cent capacity. This clearly shows that goods are sold at too low a price, and no doubt this condition is caused by price cutting to secure business. It is of major importance that our plants should be operating at a profit, and no effort should be spared by manufacturers and engineers to bring this condition about. Manufacturers can assist in this work by the elimination of obsolete equipment and making conditions better for the operatives, and engineers can do their share by developing

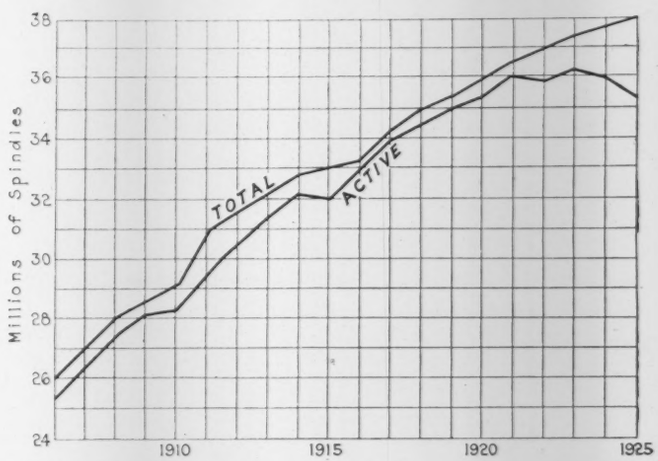

FIG. 1 COTTON SPINDLES IN THE UNITED STATES INSTALLED AND ACTIVE FROM 1905 TO 1925—FAIRCHILD'S INDEXES

improved and labor-saving machines. There is also quite a field for scientific management in the textile industry. Many plants are operating today in the same manner as they did twenty years ago. Modern methods of management must be introduced if the industry is to come back to the position it held in former successful years.

The rayon industry has increased its production during the past few years. The total rayon produced in the world in 1924 was 138,000,000 lb., and in 1925 the production was increased to 179,000,000 lb. The figures for 1926 are not yet available, but it is expected that these will exceed the production of 1925.

MACHINERY

Textile-machinery builders are putting ball and roller bearings on machines as standard equipment, and this is a step in the right direction, resulting in—

1 Smoother-running machines
2 Lower power consumption
3 More economy in the use of lubricants.

The use of high-speed twisters in the worsted industry with vertical travelers is increasing. The percentage of waste has been considerably reduced through this development.

TABLE 1 TOTAL YEARLY AVERAGE AND OPERATION OF WOOLEN AND WORSTED SPINDLES FROM 1918 TO 1925, INCLUSIVE

(From the Department of Commerce, Bureau of the Census)

	Spinning spindles	
	Woolen	Worsted
Average total, 1918	1,605,025	1,853,479
In operation	1,421,407	1,485,581
Average total, 1919	2,162,077	2,292,535
In operation	1,805,522	1,814,231
Average total, 1920	2,254,317	2,332,529
In operation	1,517,594	1,730,504
Average total, 1921	2,301,305	2,377,056
In operation	1,653,323	1,996,284
Average total, 1922	2,314,699	2,488,425
In operation	1,917,525	1,938,129
Average total, 1923	2,291,423	2,520,321
In operation	1,965,637	2,210,034
Average total, 1924	2,282,770	2,606,513
In operation	1,832,715	1,807,810
Average total, 1925	2,291,094	2,628,914
In operation	1,812,925	1,805,532

Total Consumption of Wool from 1918 to 1925, Inclusive, Lb.

1918	605,158,000	1922	555,777,000
1919	543,087,000	1923	550,878,000
1920	485,744,000	1924	460,402,000
1921	456,190,000	1925	450,021,000

Variable-speed motors and speed variators are being used generally, resulting in increased production. This equipment is rapidly replacing steam-engine drives.

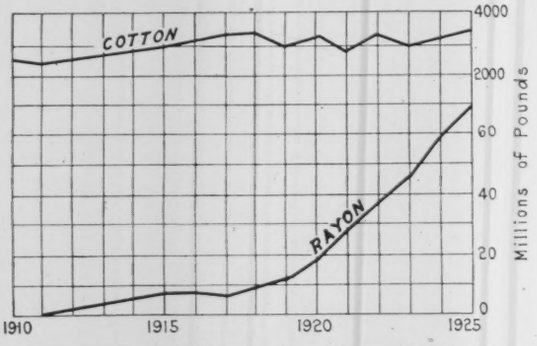

FIG. 2 COTTON AND RAYON CONSUMPTION IN THE UNITED STATES SINCE 1910—FAIRCHILD'S INDEXES

Plants equipped to build machinery for the processing of rayon goods have been generally busy during the year, and no doubt this condition will continue during the coming year.

There has been quite an increase during the year of equipment for handling goods mechanically. This applies particularly to pilers for kiers and bins. These machines are very efficient and reduce personnel considerably.

The Casablanca system of long-draft spinning has been one of the prominent improvements introduced during the present year.

POWER

The depression in the industry has no doubt been the reason why many of the old power plants have not been rebuilt and equipped with modern boilers and labor-saving machinery.

Mills which do not require steam for processing can generate power economically by the use of oil engines direct-connected to generators. There is no doubt that there is quite a field for this equipment in the above types of mills.

RESEARCH

There is a crying need for a scientific and organized research for the betterment of the mechanical operation as well as of the economical organization in the textile industry. The almost acute depression of the textile industry, while at large ascribed to market conditions, can be traced to the lack of such scientific development of the textile industry. It is a well-known fact that both basic staples, the cotton and wool, are far below the cultivation standard of the other agricultural staples of the United States. This important phase, of course, is outside of the field of the engineering profession.

Inside this field systematic research has not yet taken place in the manner necessary for the third-highest-ranking industry of the United States, the apparent reason being that most of the organizations are comparatively small when compared with such industries as the steel industry, where organizations can afford to undertake exhaustive research work, and appropriate sufficient capital for the successful operation of institutions for that purpose.

Individual plants undertaking research have to depend upon the manufacturers of textile machinery to a considerable extent for the performance of experiments. No radical improvements of mechanical procedures for production have been developed for generations, which condition should not be a reflection upon the initiative of the engineers engaged in this branch, but rather upon the lack of enterprise of those who are at the helm of the operating enterprises.

GENERAL

One of the improvements suggested in the industry is to have the lighting installations modernized. Researches have been carried on for some years, and now complete data are available so that all operations can be carried on as well with artificial light as by daylight. It was recently stated that about 6 per cent of the industrial plants in the country were properly lighted. The cost of changing over from existing conditions is nominal, and the following results are obtained:

a Increased production
b The quality of goods is improved
c The accident hazard is considerably reduced.

The latter item is of major consideration, especially when statistics show that 80 per cent of the accidents are non-mechanical. This change has been brought about by safety campaigns, regular inspections for danger points on machinery, and the guarding of machines. Many of our states make guarding of danger points compulsory, and manufacturers have coöperated in this work to a considerable extent.

OPPORTUNITY FOR ENGINEERS

There is a constantly increasing field for engineers in the industry. Many of the problems can only be solved by trained minds, and young engineers with initiative would do well to consider the opportunities before looking elsewhere. There are openings for men interested in power, construction, management, maintenance, production, material handling, and in the operating departments. Maintenance is one of the most varied, as well as the most interesting positions in textile plants. The engineer is in close contact with all operations and new developments in the plant. New processes are being developed frequently, and this calls for design of new equipment.

NEEDS OF THE INDUSTRY

The urgent need of the industry is a thoroughgoing scientific investigation of all mechanical processes, together with a similar investigation of management procedures. Summing it up, what the industry needs are standards which disregard the past procedures, customs, and accepted fallacies, and result in the total reorganization not only of the procedures of production, but also of the mechanical methods.

The need for such development was never as evident as it is now. The textile industry was always known as the industry of semi-skilled occupations, where many of the minor operations and movements of material were performed by hand, and it was also a haven of unskilled labor during the past generation. With restricted immigration this supply has been shut off; in spite of it, however, the industry has not adopted the mechanical handling of materials to the extent that it would be justified in doing by the elimination of this labor source and the corresponding increase in labor cost. As an immediate need, therefore, mechanical means of handling the product between operations could be put as the first immediate need; the next one would be the mechanization of service operations incidental to production.

The great objection to such procedure by the manufacturers themselves lies in the fact that such mechanical means of handling and the automatic arrangements of service operations are not warranted by the limited size of the average textile plant. This objection, however, is clear to engineers engaged in this branch, and is not justified because most operations are simple enough to eliminate the necessity of elaborate mechanical installations.

JAMES A. CAMPBELL, *Chairman*

Progress in Railroad Mechanical Engineering

Contributed by the Railroad Division

Executive Committee: H. B. Oatley, *Chairman*, Marion B. Richardson, *Secretary*, A. F. Stuebing, R. S. McConnell, Wm. Elmer, and Elliot Sumner

DURING the current year progress in railroad mechanical engineering, as related to motive power and rolling stock, has continued steadily along the lines which have been indicated in previous reports submitted to the Society by this Division.

This progress may be summed up by saying that there has been movement toward the greater effectiveness and earning capacity of equipment. In the case of motive power, the aim has been to obtain more ton-miles per hour at a reduced operating and maintenance cost. In the case of rolling stock, it has been toward standardization of design and construction, and also toward the development of materials and methods which increase the life of cars and reduce cost of maintenance and time out of service.

This report will briefly discuss the following:

A—Motive Power:
- 1 Higher steam pressures
- 2 Higher steam temperatures
- 3 Greater sustained capacity
- 4 Internal-combustion engines
- 5 Three-cylinder locomotives
- 6 Back-pressure gages
- 7 Unit cars for rail operation
- 8 Unit cars for non-rail operation
- 9 Motor buses
- 10 Transmissions
- 11 Longer locomotive runs.

B—Rolling Stock:
- 1 Standardization
- 2 Roller bearings.

C—Trend in Development:
- 1 Steam motive power
- 2 Internal-combustion motive power
- 3 Rolling stock (non-powered).

D—Union-Management Coöperation.

E—Power Brake Tests.

F—Bibliography.

Motive Power

Higher Steam Pressures. High steam pressures have been used to a greater degree in newer locomotives than in any preceding year. Orders have been placed for more than 400 large and economical locomotives, many of which have been completed during the present year. The Pennsylvania Railroad ordered 200 4-8-2 type locomotives with 250 lb. pressure, the Illinois Central 50 2-8-4 locomotives carrying 240 lb. pressure, the New York Central 25 additional 2-8-4 type freight locomotives carrying 240 lb. pressure, and the Northern Pacific 12 4-8-4 type locomotives with 240 lb. pressure. The Baldwin Locomotive Works built one 4-10-2 type engine carrying 350 lb. pressure. Abroad the use of higher steam pressures had made headway, the most striking example being the 4-6-0 three-cylinder compound locomotive built by Henschel & Son, of Germany, to the designs of the Schmidt' sche Heissdampf Gesellschaft and carrying three different boiler pressures, namely, 1200, 900, and 200 lb. per sq. in. More detailed description of this very novel and interesting locomotive design will be submitted to the Society at the Annual Meeting in a paper by Professors Schmidt and Snodgrass, offered by the Railroad Division. The report of the American Railway Association's Committee on Locomotive Design and Construction, presented at the 1926 meeting of that Association, made interesting reference to the 4-8-2 type locomotive, carrying 250 lb. boiler pressure, placed in service and tested by the New York, New Haven & Hartford Railroad. This locomotive showed an increase of 15½ per cent in thermal efficiency over a similar locomotive carrying 200 lb. pressure, having a radial stay firebox instead of a McClellon water-tube firebox, and having 85 per cent maximum cut-off as compared with the 70 per cent maximum cut-off of the high-pressure engine.

Consideration of increase in steam pressure necessitates consideration of boiler and firebox construction better adapted to the higher pressures. That these higher pressures may require a modification in the firebox structure is evidenced by the consideration that has been given the use of water tubes and the partial, or complete, elimination of flat stayed surfaces. The Baldwin experimental locomotive, the McClellon firebox on the New York, New Haven & Hartford, and the very interesting water-tube firebox on the Schmidt-Henschel locomotive are developments which are along the lines of progress, both as to suitability for the higher boiler pressures and, as is indicated, at least in the case of the McClellon firebox, in a reduction in maintenance and repair cost.

Higher Steam Temperatures. The increase in steam temperature has been of steady growth for a decade or more, and while the maximum temperature, with materials available at present, has been quite closely approximated in a good many cases, there is abundant evidence that motive-power officials are cognizant of the fact that additional advantage will accrue from a further increase in steam temperature. With the increasing demands for greater capacity in locomotives, attention has been turned to the Type "E" superheater, which has been growing in favor during the past four or five years. A large majority of all the high-capacity locomotives built during the past year have been fitted with this type of superheater. Reference to Table 1 will prove interesting in this connection.

Greater Sustained Capacity. Greater sustained capacity of the modern locomotive is one of the goals toward which progress is continually being made. Greater power output per unit of weight of locomotive is demanded. Locomotive builders, and all others associated in the development of new motive power having steam or internal-combustion prime movers, have bent their efforts in this direction. It is interesting to note that the Canadian Pacific in some 4-6-2 and 2-8-2 type locomotives built during the present year adopted an alloy steel for boiler-shell plates in order that, for the 250 lb. boiler pressure being carried, the boiler weights would not be increased. This means an increase in the output per pound of locomotive weight and should result in a reduction in operating cost. The use of superheated steam for locomotive auxiliary apparatus has been made possible at all times by the use of a throttle located between the superheater and the steam chest. In addition to a reduction in the fuel costs there has been an increase in the sustained capacity of the boilers, because the thermal savings resulting from the use of superheated steam by the auxiliaries have left a larger amount of power available for the main engine. Adoption of this feature has been characteristic of new locomotive building during 1926.

The use of larger grates and increased combustion volumes in fireboxes has contributed to better firebox efficiency and may properly be considered as a mark of progress in locomotive design. The use of boosters on trailing and tender trucks has increased the effectiveness of locomotives by giving them increased power at starting and in many instances has avoided the use of pusher engines, thus decreasing operating costs. The additional first costs and maintenance expenses are probably well warranted in many cases, but it is questionable if, in some classes of service, such additional costs will always be justified. A marked increase in the utilization of exhaust steam for feedwater heating has characterized locomotive construction of the current year. Feedwater heaters of both the pump-driven and injector type have been

applied in a large number of the outstanding modern locomotives built during the year.

Mention may be made of the 4-12-2-type three-cylinder locomotives built for the Union Pacific, which are the largest and most powerful non-articulated engines ever constructed. A high sustained boiler capacity was desired and has been fully realized in this design, produced jointly by the American Locomotive Company and the Union Pacific. Type "E" superheaters and feedwater heaters contributed largely to this result. There was also a very effective use of the adhesive weight, made possible by the use of three cylinders, producing a more even torque on the drivers. There is also noted a growing preference for the use of cast-steel cylinders because of the resulting decrease in weight and also for the reason that this material affords the greater strength required by the higher boiler pressures now being used. Progress in design is reflected by the use of such material.

TABLE 1 DATA SUMMARIZING PROGRESS IN MOTIVE POWER AND ROLLING STOCK DURING 1926

STEAM LOCOMOTIVES

Road	Type of locomotive	Boiler pressure, lb. per sq. in.	No. of cylinders	Type of superheater	Max. cylinder hp.	Back pressure gage	Feedwater heater, pump or injector type	Max. cut-off, per cent	Throttle between superheater and steam chest	Grate area, sq. ft. Total	Grate area, sq. ft. Per 100 hp.
N. P. Ry.	4–8–4	240	2	E	3384	Yes	Ex. Inj.	85	Yes	115	3.39
U. P. Sys.	4–12–2	220	3	E	4329	Yes	Pump	85	No	108	2.49
B. L. W.	4–10–2	350	3[1]	A	3800	No	Pump	90–70	Yes	82.5	2.17
C. P. Ry.	4–6–2	250	2	A	2203	Yes	Pump	80	Yes	66.8	3.03
C. P. Ry.	2–8–2	250	2	A	2203	Yes	Pump	80	Yes	70.3	3.19
P. R. R.	4–8–2	250	2	E	3017	No	None	80	No	69.9	2.32
C. St. P. M. & O.	2–8–2	210	2	E	2755	Yes	Ex. Inj.	85	Yes	70.8	2.57
P. L. & M.	4–8–2	225	4[1]	A	1831	No	None	75	No	53.8	2.94
I. C.	2–8–4	230	2	E	3000	Yes	Pump	55	Yes	100.0	3.33
H. S. G.	4–6–0	900 and 200	3[1]	E(2)	1993	No	Pump	...	No	28	1.405
N. Y., N. H. & H.	4–8–2	265	3	E	3200	Yes	Pump	85	Yes	70.8	2.21
N. Y., N. H. & H.	4–8–2	265	2	E	3217	Yes	Pump	70	Yes	70.8	2.28

[1] Compound.

INTERNAL-COMBUSTION LOCOMOTIVES

Road	Type of locomotive	Motors Units	Motors Hp., total	Weight, lb.	Length ft-in.	Transmission
Baldwin	0–6–6–0	1	1000	275,000	52–1¾	Electric
C. R. R. of N. J.	0–4–4–0	1	300	130,000	...	Electric
Long Island	0–4–4–0	2	600	200,000	40–0	Electric
Russia (Sov. Gov.)	4–12–2	..	1200	275,000	54–9¾	Gear

INTERNAL-COMBUSTION RAIL CARS

Road	Motors Units	Motors Hp., total	Weight, lb.	Length, ft-in.	Transmission	Passenger capacity	Heating system
B. & M.	...	275	100,000	73–5/8	Electric	92	Radiators Electric (Hot water)
C. B. & Q.	2	120	39,000	43–0	Gears	41	....
C. & G. W.	...	180	53,000 motor	102–0 with trailer	Gears	...	....
C. & N. W.	...	225	90,000	76–6	Electric	45	....
N. Y., N. H. & H.	...	...	74,000	74–7¼	Electric	120	....
Reading	...	250	....	60–0	Electric	50	Baker
Sus. & N. Y.	2	150	....	57–0	Gears	57	Hot water

INTERNAL-COMBUSTION NON-RAIL CARS

Road	No. of buses	Type	Length, ft-in.	Transmission	No. passengers	Make
A. T. & S. F.	19	4-wheel	..	...	18-up	White
B. & M.	53	4-wheel	...	...	...	Various
C. & A.	2	8-wheel 4-axle	35–6	Electric	33–37	Versare Corp.
G. N.	140	4-wheel	..	...	18-up	Various
N. E. T. (N. Y., N. H. & H.)	166	...	..	...	25–30	Various

Internal-Combustion Engines. Use of the internal-combustion engine has also continued and is an indication of the desire to provide a lower operating cost of motor units where conditions are not as well met by the steam locomotive. An increasing number of yard locomotives of the Diesel-electric type have been ordered, and indications are that for certain purposes such locomotives possess advantageous features and that their use will be extended in the next few years.

A 4-10-2-type Diesel locomotive was built early in the year by the Hohenzollern Locomotive Works, Düsseldorf, Germany, in collaboration with Prof. George Lomonossoff and the Magnet-Werk, Eisenach, equipped with a 1200-b.hp. M.A.N. Diesel engine and gear-transmission system. The weight of the locomotive in working order is 275,000 lb. The maximum tractive force is 42,000 lb. at 4 m.p.h. The maximum speed is 34.5 m.p.h. The speed stages, of which there are three in the gear-transmission system, are controlled by high-power electromagnetic clutches. This locomotive has been subjected to extended tests on the locomotive testing plant at Düsseldorf and also has been undergoing road tests since May 1, last, on the German State Railways. It is reported that this Diesel locomotive starts smoother than a steam locomotive, even with heavy trains on grades, and that the control of the clutches has proved entirely satisfactory; also that the speed changes are accomplished without the slightest shocks. After 2600 miles in heavy freight service and more than 1000 main-clutch operations, the wear of the friction lining was found to be 0.011 in.

Three-Cylinder Locomotives. The three-cylinder locomotive, to which reference has already been made, has been built in larger numbers during the past year. While the four-cylinder engine has not made its appearance in this country, or Canada, in recent years, an interesting locomotive has been built abroad and data concerning its performance have appeared during the year. This engine is a 4-8-2 type, built for the Paris, Lyons & Mediterranean, having four cylinders compounded. A very marked improvement in operating conditions is reported from this locomotive. From the standpoint of lowering the permissible factor of adhesion, a four-cylinder locomotive offers equal, or greater, opportunities than even the three-cylinder locomotive, although the cranked driving axle is a feature which American railroad motive-power officials will accept only after demonstration.

The builders, and railroad motive-power officials who have contributed to this report, express confident belief that the use of the three-cylinder principle, as well as the use of the limited cut-off, are aiding in the still greater effectiveness and permitting further increase in the power and sustained capacity of the modern locomotive. There is great unanimity of opinion that the larger sizes of units aer very necessary and that the end is not yet in sight. The remarkable increase in earning capacity of freight locomotives, as measured by more gross ton-miles per train-hour, during the past year is very significant and offers encouragement for the future. Published information of the records made by the 2-8-4 locomotives on the B. & A. and the 2-10-4 locomotives on the Texas & Pacific support the statements which have just been made.

Back-Pressure Gages. The number of locomotives during the year which have been fitted with gages enabling the engineer to observe pressures existing in the exhaust passages show clearly that operating advantage is appreciated and that effort are being made to still further improve the operating effectiveness. Most of the installations of the exhaust-steam injector include a gage for registering within easy view of the engineer the back pressure in the cylinders. The installation of gages which show steam-chest pressures has also taken place within the current year. By means of such gages the engineer is enabled to determine conditions under which the maximum power of the engine can best and most effectively be developed. Apparatus which shows the engineer the steam-chest pressure and the cylinder back pressure are progressive moves in the development of the locomotive.

Unit Cars for Rail Operation. A large number of unit cars for rail operation have been ordered during the year and some of these have been placed in service. The Boston & Maine, the Canadian National, the Lehigh Valley, the New York, New Haven & Hartford, and other roads having made careful studies, have tried out motive power of this character for branch-line operation with encouraging results. The Boston & Maine, owing to its peculiar operating conditions, is perhaps the largest user of this type of equipment, with a total of 24 rail motor cars in service. This road purchased

10 rail motor cars of all-steel construction and placed them in service during the months of August and September. Two cars are designed primarily for main-line local service and are equipped with automatic train control.

There is no question but what progress is being made, and will continue to be made, in the development of larger and more powerful cars, but there is also no question but that there is a limit to the economical operation of a gas engine and a point where the steam locomotive, for sometime to come, will make the better showing.

Motor Buses and Trucks. For non-rail operation the railroads have found available the internal-combustion engine using gasoline as fuel, and during the past year there has been a marked increase in the use of buses thus powered. As a supplement to, and an extension of, rail transportation, the bus has offered an attractive combination of motive power and vehicle. It is probably too early to draw any conclusions as to how efficient, from a transportation standpoint, equipment of this sort will become. A number of strong organizations are actively engaged in developing it and a very marked advance both in power capacity as well as in effectiveness of operation will assuredly be noted within the next few years. It is not too much to expect that this form of motive power and vehicle will open up to the transportation systems of the country a means of expediting, at reduced cost, the short-haul gathering and distribution of freight between warehouse, shop, or store and the long-haul, rail-carried freight car. The increased use of motor trucks for delivering less-than-carload freight from main terminals to the adjacent towns has probably contributed as much as anything else to the increased freight-car mileage and increased average carload by the elimination of way freight. Transportation of passengers from central points through thickly congested urban territory to main-line terminals is also forecast as an extension of passenger-transportation service. The recent introduction by the Baltimore & Ohio Railroad of service between the heart of Manhattan and the Jersey City terminal of the Central Railway of New Jersey is an indication of this development.

It is estimated that there are in operation today more than 70,000 motor buses. Of these, a comparatively small proportion are owned, directly or indirectly, by the steam railways. The results being obtained by such steam-railway pioneers in bus operation as the Spokane, Portland & Seattle, the New York, New Haven & Hartford, and the Boston & Maine, and in the use of trucks for freight haulage by the Lehigh Valley and the Pennsylvania, have attracted universal attention and close study on the part of the traffic and mechanical departments of the majority of our railroads. The New York, New Haven & Hartford and the Great Northern, as well as a number of other railroads, have definitely committed themselves to the utilization of motor buses for passenger haulage. The Boston & Maine, the New York Central, the Pennsylvania, and a number of other roads have also gone quite extensively into the utilization of trucks for freight haulage. In most cases the motor-transport work is under the supervision of a subsidiary company. Just what effect this development will have on the work of the mechanical department of the railroads it is difficult to tell at the present time. This development, going along hand in hand with that of the gasoline rail motor car, has raised a question as to the possibilities of combined maintenance of these two types of equipment. During the past year a number of mechanical-department officers have been transferred from work pertaining to steam locomotives to that of maintenance of gasoline equipment.

At the present time the steam-powered bus, for non-rail use, has made but little headway in this country. One steam-driven highway bus is in operation in the city of Detroit. Steam-driven tractors and automobiles have from time to time made their appearance in this country, but not to the extent that they have been used in England and on the Continent. There are indications that this form of power is being developed, and further exploitation of steam as a competitor of the internal-combustion engine may appear in the not-far-distant future.

Transmissions. Development of transmissions other than electric is a field of activity in which time and money are being spent and is evidence that progress is being made. Hydraulic and gear transmissions are being experimentally developed with the object of handling larger power units. There has been some improvement in the refinement of apparatus to protect the electric equipment from damage.

Longer Locomotive Runs. Longer locomotive runs are evidences of a realization of fundamental economic locomotive operation, and have been responsible in no small degree for the improvement in operation of our railroads during the past year. Tests indicate that coal-burning locomotives can be operated past intermediate terminals and over as great distances as oil burners, as far as fire conditions are concerned. This is due in a large measure to the fact that locomotives are being equipped with more efficient mechanical devices designed to improve the overall efficiency of the locomotive as a power unit. For a considerable period the New York Central operated one of its trains a distance of about 1000 miles between New York and Chicago without changing engines. In one test the Chicago, Burlington & Quincy operated a locomotive in mixed-train service a distance of 2645 miles with a single fire, the life of the fire being more than 183 hours. It was the consensus of opinion that the fire could have been continued indefinitely, burning the average run of coal on the divisions in question. A coal-burning locomotive was operated about 2000 miles by the Northern Pacific without receiving any terminal attention en route or being uncoupled from the train. Four grades of coal, largely lignite in character, were burned. The Terminal Railroad Association of St. Louis has operated four switch engines in continuous service for a period of thirty days without having the fires cleaned. This shows what can be accomplished, and is an indication of what can be expected of modern steam locomotives.

ROLLING STOCK

Standardization. Developments in rolling stock (non-powered freight and passenger cars) have been greater than generally supposed. The most notable example of progress is the development of freight cars of standard design and construction. This work, which is being conducted under the supervision of the Committee on Car Construction, Division V, Mechanical, of the American Railway Association, has resulted in the adoption, by many members of that association, of a major part of the standard design of 40- and 50-ton single-sheathed and the standard 40- and 50-ton double-sheathed box car. At the annual convention at Atlantic City this year the Committee submitted tentative designs for standard automobile cars and for 50- and 70-ton self-clearing hopper cars. Progress is also being made in the design of standard stock cars. The A.R.A. Committee on Car Construction is also working on specifications for fundamental calculations for the design of box cars, and is conducting an elaborate series of tests of cast-steel truck side frames. This work is probably the greatest progressive step toward uniformity in car design which has yet been made.

The greatest demand for standardization has come from the railroads that use the cars rather than from the manufacturer who builds them. It is to be expected that further progress in these activities will be made in the near future and that railroads and car-manufacturing companies will coöperate to the fullest extent.

Roller Bearings. The past year has also indicated a growing interest in the application of roller bearings to passenger-car equipment, and a number of roller-bearing trucks were exhibited at the last A.R.A. convention. It is safe to say that more progress has been made during the past two years in the perfection of an anti-friction bearing for car trucks than during the preceding fifteen years. Since 1924 attention has been directed to the improvement of the chemical analysis of the steel used in the bearings, to refinement in workmanship, and to proper design as regards caring for the end thrust. These have been weak points in most designs. The fact that many railroads have one or more passenger cars equipped with some type of anti-friction bearing is indicative of a growing realization among railway men of the possibilities offered by such bearings for reducing starting resistances, for increasing train lengths, and for reducing journal-box maintenance costs and hot boxes. Interesting data should be developed within the next year or two which will aid materially in perfecting anti-friction bearings for railway use.

In the matter of repairs, it may be said that the railroads have continued to make noteworthy advances in the use of gages, templets, jigs, and other shop equipment with the aim of reducing the cost of car repairs and decreasing the time out of service. The benefits, direct and indirect, resulting from this practice are indicative of progress in this field of railroad mechanical engineering. Information received by the Committee indicates that extension of this work is being studied with care, and that still further improvements will be effected.

TREND IN DEVELOPMENT

Steam Motive Power. The trend in the development of motive power is unmistakably toward larger units of power, whether steam or internal-combustion-engine driven. With steam-driven motive power there is also a very clear trend toward the use of higher steam pressures and higher steam temperatures, and such features of design as have been referred to in the foregoing portions of this Report, with an aim to still further reduce the cost of operation and to increase the earning power of the locomotives. It may be interesting to note the improved performance of the Class I railroads in this country between 1920 and 1925 (Table 2).

TABLE 2 IMPROVEMENT IN PERFORMANCE OF CLASS I RAILROADS, 1920–1925

	1920	1925	Per cent change from 1920
Average speed of trains (freight), m.p.h.	10.3	11.8	+14.5
Average gross wt. of train (freight) exclusive of engine and tender, tons	1443	1670	+15.7
Fuel per 1000 gross ton-miles (freight), lb.	162[1]	140	−13.7
Average cars per train (passenger)	6.44	6.72	+ 4.35
Fuel per car-mile (passenger), lb.	18.8	16.1	−14.37

[1] Figure given is for 1921.

Not only is there shown a progressive and important decrease in the fuel consumed in both freight and passenger service, but the gross ton-miles per train-hour have, between 1922 and 1925, shown an increase of 21.6 per cent. This is progress not only in moving more revenue-producing tons per train, but in moving them at higher speed. The miles per car per day has also shown progressive increase during the past five years, and is continuing during the current year. This daily average for the first seven months of 1926 compared with the corresponding period in 1925 shows an increase from 26.9 to 29.2 miles (or 8.5 per cent) per day. This increase is of course the reflection of heavier and faster trains, better condition of equipment, more prompt loading and unloading of cars, and more rapid handling of equipment in classification and terminal yards. These figures are all indicative of progress in railroad mechanical engineering.

Internal-Combustion Motive Power. The trend in the development of the internal-combustion-engine-driven motive-power unit is toward a decrease in the weight of engine per indicated horsepower. The rail-borne equipment of this type in use on the Canadian National Railways represents a very marked step in this direction, and leads to the expectation that equality in weight per unit of power developed comparable with the steam locomotive of present-day design will be obtained. Another aim on the part of the designers of the internal-combustion-driven motive power is the satisfactory utilization of fuel having a still lower initial cost per gallon, and there is indication that progress is being made in this direction.

Rolling Stock (Non-Powered). The trend in development of non-powered rolling stock may be said to be toward greater standardization of design and maintenance methods, the increasing use of the 100,000-lb. or larger, capacity car, and the use of material which will be less subject to deterioration from corrosion and hard usage. There is also to be noted a return to the use of composite wood and steel construction for conveyance of commodities which, by their chemical action, destroy steel sides and floors.

UNION-MANAGEMENT COÖPERATION

No report of the progress made in the railroad industry during the past year would be complete without mention of the joint meeting on February 5, 1926, of the Taylor Society, the Metropolitan Section and the Management Division of the A. S.M.E., and a number of other organizations. This was the first formal presentation of the subject, Union-Management Coöperation in the Railway Industry, under the auspices of a scientific body. The principles and workings, as well as the advantages, of what is commonly known as the Baltimore & Ohio plan were discussed by Otto S. Beyer, Jr., the consulting engineer who developed the plan as an advisor to the shop-crafts unions. This was followed by an address giving organized labor's appraisal of the plan by Bert M. Jewell, president of Railway Employees Department of the American Federation of Labor. The meeting closed with an appraisal from the standpoint of the management by Sir Henry Thornton, president of the Canadian National Railways.

POWER BRAKE TESTS AT PURDUE

The American Railway Association appointed H. A. Johnston director of research in December, 1924, and authorized expenditures for a new test rack and power brake equipment at Purdue University, with the object of making a thorough and unbiased investigation which would indicate, beyond a doubt, what type of equipment, either now in use or to be subsequently developed, is best adapted to meet the demand of the I.C.C. for improved power train brakes. During the past year a staff of thirty specially trained men have been working 44 hours a week on 565 separate tests.

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The Committee wishes to acknowledge its indebtedness to all those companies and individuals that have expressed their opinions and submitted data from which this Report has been made.

H. B. OATLEY, *Chairman*

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GENERAL

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Helium Tank Car, *Railway Review*, vol. 78, p. 673, Apr. 10, 1926. Large cylinders reduce loss of 15 per cent where small cylinder is used.

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Report of Pneumatic Brake Tests, *Railway Age*, vol. 80, pp. 1141–1143, Apr. 24, 1926. Quick-service valve reduces rough handling.

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H. B. OATLEY, *Chairman*

The fact that the new battleship *Nelson* is being completed on the Tyne in a veil of secrecy makes it interesting to remember that it is just fifty years ago that her predecessor of the name was launched.

The *Nelson* had a displacement of 7640 tons, and was only partially protected on the water-line with a belt of compound armour 9 in. thick amidships and tapering towards the athwartship bulkheads. Her armament consisted of four 18-ton muzzle-loading rifles, eight 12-ton muzzle loaders, and two 14-in. torpedo tubes. As a cruising ship she was intended to spend a large proportion of her time under sail, and was a far better sailer than most of the ironclads of her day.

Her engines were interesting; they consisted of two sets of inverted vertical compound engines with cylinders 60 and 104 in. in diameter, with a stroke of 42 in., designed to run at 75 r.p.m. They had modified Allan valve gear and were regarded as being remarkably strong built. The engines were fed by 10 boilers, each with three furnaces, set athwartships in four boiler rooms. These boilers were each 12 ft. 6 in. wide by 14 ft. 6 in. high by 9 ft. 6 in. long, and were designed for a pressure of 60 lb. per sq. in. The propellers were outward turning and consisted of two tow-bladed screws on each shaft.

On her six-hour trial the *Nelson* developed an indicated horsepower of 6246 at 79 r.p.m., giving her a speed of 14 knots. The specific fuel consumption worked out at 2 lb. of coal per indicated horsepower per hour. On a four-hour, half-power trial, with 60 lb. steam pressure and 63 r.p.m., she developed 3083 i.hp., while one engine gave her 10.6 knots with 2995 i.hp. (*The Marine Engineer and Motorship Builder*, November, 1926.)

Progress in Aeronautics

Contributed by the Aeronautics Division

Executive Committee: Edwin E. Aldrin, *Chairman*, A. Klemin, *Secretary*, George J. Mead, Archibald Black, C. F. Kettering, and William Knight

Governmental Activities

ONE of the important consequences of the House inquiry into American aeronautics and of the Morrow Air Board appointed by the President himself, was the passing of the Army Air Corps Act. This provides for a considerable extension of personnel and equipment, bringing the number of officers up to 1514, the number of enlisted men to 16,000, and the number of service airplanes up to 1800. The program of expansion is to cover a period of five years and gives assurance of a steady stream of orders to the airplane industry. The Army Air Corps is now in charge of a specially appointed Assistant Secretary of War, F. Trubee Davison.

A similar appointment has been made in the Navy Department, where Assistant Secretary Edward P. Warner will also supervise a five-year program of steady expansion and development.

Both Army and Navy have been concerned with the development of airplanes and airplane engines and equipment. But in the field of lighter-than-air craft the Army has restricted itself to comparatively small non-rigid and semi-rigid, airships. The Navy, undeterred by the *Shenandoah* disaster, is now planning the construction of two huge airships of approximately 6,000,000 cu. ft. gas capacity.

The outstanding event in governmental aeronautics for the present year 1926 has been, however, the passing of the Air Commerce Act which vests with the Department of Commerce the duty of regulating air navigation. William P. MacCracken, Jr., Assistant Secretary, Aeronautics Branch of the Department of Commerce, is charged with the licensing of pilots and mechanics, the certification for airworthiness of aircraft, and the collection and dissemination of information pertaining to air commerce. He is also surveying a number of airways, and establishing emergency fields and beacons for night flying along such routes. The initial appropriation for the Aeronautics Branch is comparatively small, $250,000 being provided for administration and air regulation and $300,000 for the establishment of aids to navigation, but it is expected that subsequent appropriations will allow civil airways to be extended over the entire territory of the United States.

Air Transport

An earnest effort to expand the system of air transport in the United States has been made in the last twelve months. For many years this country maintained a scheduled air transport only through the operation of the Governmental Air Mail Service, but in 1925 a Federal Act authorizing the Postmaster General to grant contracts for the carrying of mail by air to private concerns gave a tremendous impetus to American air transport. At least fifteen Air Mail contract routes have been put into operation during the year, mainly as feeder lines to the great transcontinental service from New York to San Francisco and covering such routes as Boston to New York, Chicago to St. Louis, Salt Lake City to Los Angeles, etc. The Post Office Department has also asked for bids whereby the transcontinental airway may itself be turned over to private interests, and a rapid extension of Air Mail contract services may be expected in the near future. While most of these routes have now been in technically successful operation for several months, only a few of them are covering their expenses, and they may be said to be passing through a period of probation. The total flying mileage for 1927 in the United States is estimated at over 9,000,000.

The mileage in Europe, in the most important countries, was as follows: Germany, 3,070,000; France, 2,946,000; Great Britain, 865,000 (this does not include military flying).

The character of aviation in Europe is, however, entirely different from that in the United States, in that (1) European commercial aviation is largely based on a foundation of subsidies, and (2) instead of primarily carrying mails, as in the United States, they are engaged in the carriage of passengers and package freight. As regards subsidies, the German Government appears to have either modified or discontinued them, and this is said to have been the cause of the temporary collapse of the great Junkers system.

Another gratifying feature in the development of American aviation in the past year is the tendency to get away from the carriage of mails as the main purpose. An earnest effort is being made to extend the aircraft service to the carriage of passengers and freight. Thus, the Philadelphia Rapid Transit Company put into regular operation a passenger service between Washington and Philadelphia which was patronized very largely in the summer months. The American Railway Express Company has made arrangements with the National Air Transport Company for carrying certain classes of parcels between New York and Chicago, and other developments are under consideration.

In the Schneider Cup race in November, four out of the six machines which started finished the gruelling race of 350 km. Three out of four of the machines that finished showed an average speed in excess of 225 m.p.h. The fourth machine need not be counted in this connection as it was not one intended for the race, but merely a last-minute substitute for a racing plane that collapsed in a preliminary test. The fact that such high speeds have been developed in seaplanes speaks well for the plane construction and engine reliability, and is an evidence of the high state already attained by the aeronautical art. The first place in the race was taken by a Macchi Italian monoplane, and the second place at only a slightly inferior speed by a Curtiss machine owned by the Marine Corps.

Aids to Navigation

The earth inductor compass which substitutes an armature rotating in the earth's field for the usual magnetic needle, and in which indications are read at a distance so that the compass may be placed where the effect of metallic parts is reduced to a minimum, has proved highly useful in service. The British Air Ministry has reported successful trials of another useful instrument, the gyro rudder control. This apparatus, which relieves the pilot from strain in keeping a course in a long flight, consists essentially of a gyro wheel, a compressed-air reservoir, and two cylinders and pistons, the latter being connected to a false rudder bar, which again is connected to the main rudder bar. As the aircraft turns, the gyro operates the false rudder bar. The directional wireless beacon has during the year passed through the experimental stage at the hands of the Army Air Corps and is now being considered for installation on the airways surveyed by the Department of Commerce; the radio beacon gives the pilot a signal which keeps him almost infallibly on a straight course. Experiments with neon lights are being conducted both by the British Air Ministry and by the National Air Transport Company at Moline, Ill. In the neon light a voltage of several thousand is applied at two terminals in a glass tube 10 ft. in length filled with pure neon gas; a light of a peculiar orange-reddish color is obtained which is proving to have great penetrating power in fog. The British are experimenting with field localizers in which wires carrying an alternating current are laid round an airdrome and help the pilot to land in a fog. It is hoped that with huge light beacons, radio direction beacons, field localizers, and height altimeters of the capacity type, flying may soon become possible under all conditions of low visibility, whether of night or fog.

Aerodynamics

The theoretical foundations of aeronautics are constantly being

placed on a firmer and firmer basis. The application of hydrodynamics to aeronautical problems, the extension of the Lanchester-Prandtl vortex theory, and other theoretical developments now allow the designer to predict the aerodynamic characteristics of airfoils and other bodies with considerable accuracy.

In the past year a number of service planes have exhibited a peculiar type of "flat spin" from which pilots have found it impossible to recover, although alighting without much damage other than to the landing gear. In the "flat spin" the entire plane revolves like a giant windmill, but the parachutal effect of the wings is so high that the vertical velocity of descent is only moderate. The phenomenon is being actively studied.

Accidents other than those due to power-plant failure are frequently due to a phenomenon known as "stalling." When the wing of a plane meets the air at an angle of attack higher than a certain critical value known as the "burble point," the wing loses lift rapidly and tends to dive down by the nose. At the same time lateral control is lost and a slight deviation from an even keel frequently leads to a "spinning nose dive." If the front edge of the wing is provided with a so-called Handley Page slot (invented in 1923), in practice a thin sheet of metal covering the front rounded portion of the wing, and if at the stalling point the slot is opened, a venturi-like passage is created at the front edge, and the lift no longer decreases when the angle of attack goes beyond the "burble point." Stalling is thus readily avoided. The maximum lift coefficient of the airfoil is also increased by means of this device and a lower landing speed becomes possible. Equipped with the Handley-Page slot, a machine can also glide down at a steep angle to the horizontal without attaining excessive speed, and is thus able to land in more restricted territory. While no planes have been as yet equipped with the Handley-Page slot in the United States, several planes for deck landing and a number of commercial craft employing this device have been built both in England and Germany. The Handley-Page slot has also been applied with success to aileron control, which becomes less operative and introduces a tendency to turn the machine dangerously off its straight course at slow speeds.

Many designers claim, however, that a machine perfectly safe and controllable at the "stall" can be produced by skilful application of conventional forms, and Fokker, the well-known Dutch designer, has apparently been successful with several types in maintaining perfect control and avoiding spins at high angles of attack.

The problem of slow landing and of descent on a steep path has been attacked in an entirely different direction by the Spaniard LaCierva in his machine known as the "autogyro," which is, however, not an airplane at all, as it is generally understood. The autogyro obtains its lift not by conventional fixed wings, but by a set of blades revolving about an axis set almost in a vertical position. These blades are not driven by the engine, but are so acted on by the air when the craft is in motion that they revolve freely like a huge windmill and thus provide a lifting power for the machine. The autogyro is, however, only at the very beginning of its development and it is premature to say whether or not it will ever become a commercially practical machine. Thus far it has shown an ability to descend at a slower rate than conventional airplanes of similar size (vertical descent of 15 ft. per sec. at an angle of 30 deg. to the horizontal), but its translational speed is still very low.

In England, Captain Hill has attacked the problem of control at low speeds and avoidance of the stall in still another direction by means of his so-called "tailless airplane" or "Pterodactyl." Strictly speaking, the Hill Pterodactyl is not a tailless airplane: rather has the tail been attached at the end of heavily swept-back wings. By sweeping back the wing and reversing the trailing edge a constant center of pressure has been obtained, obviating a tendency to nose diving. At the end of the wings are placed "controllers" which are so hinged as to be always in the line of the wind, and therefore retain their effectiveness when the wing itself is at the burble point. Effective control is thus maintained in almost any flight altitude.

The Germans, prevented from using large engines by the provisions of the Treaty of Versailles, and compelled to use low-power plants, have developed several types of wings of very high efficiency and have generally made material progress in the design of their planes.

Airplane Construction

In the structure of the airplane, metal is rapidly supplanting wood as the main material relied upon. On the other hand, however, the recent flights by Alan Cobham from Cairo to the Cape and back, from London to Rangoon and back, and from London to Australia and back, in which his planes had to go through all sorts of climate and weather conditions, have shown that in so far as reliability is concerned the wooden or mixed metal-wood plane can still hold its own. Increasing attention is being paid to the metal plane, because it is believed that should a really great expansion in airplane building take place there would be a shortage of the necessary kinds of woods, while metal parts can be supplied in practically unlimited quantity.

Fuselages or bodies of airplanes of every possible type are now almost exclusively built of steel or duralumin tubing, with welding largely used to replace wires and fittings when steel tubing is employed. In internally braced monoplane wings the weight of the wings increases rapidly with dimensions. This difficulty is being met by Army experiments with multi-spar construction, where three or more spars are utilized in such fashion as to distribute the load with greater equalization between them under different conditions of air pressure or travel of the center of pressure. The use of duralumin is extending rapidly; this light and strong metal is adapted to airplane construction and is being utilized for fittings, bolts, tubes, and other small parts of the plane as well as in the main structural members as the spars. Rib construction in duralumin is particularly interesting, as huge ribs several feet in length weigh only a few ounces and sustain breaking loads of hundreds of pounds.

The Navy is concentrating attention on airplanes which can successfully coöperate with the fleet in scouting, artillery gun-fire spotting, and bombing and torpedo operations. The Navy is also building large twin-engined flying boats, for long-distance work and operations where distant land bases rather than the fleet itself are used for support. The Army is improving its pursuit planes, which now attain speeds of over 175 m.p.h. fully loaded.

In Europe intensive work is being done on the building of big planes. Several such types have been announced by Junkers. It is also known that the British Navy built a seaplane which is little less than a flying cruiser and can rise or land on extremely rough water. The French are said to have carried out extensive tests in the past year with new types of torpedo planes.

In commercial airplanes the disappearance of war-built material has been very marked during the past year. A number of small commercial airplanes of about 100 hp., carrying a pilot and two passengers, have made their appearance on the market at prices not much over $2500 and have found a ready sale. In the Air-Mail contract routes there have appeared a number of craft equipped with the Wright J-4 air-cooled engine of 200 hp. and carrying 500 lb. of mail at cruising speeds of over 100 m.p.h. Great interest has been shown in the three-engine type of craft. With multi-engines the probability of forced landing by virtue of engine failure is greatly reduced, and the Fokker FVII and the Ford three-engined transport planes have proved conclusively that flight with a full load of passengers, gas, and oil can be maintained on any two of the three engines, and that with only one engine in commission a long glide can be made in search of an emergency landing field. The useful load carried by the modern passenger- or mail-carrying airplane is now well over 50 per cent of the entire gross weight. The pay load in a British-built air freighter is to be 8 lb. per hp., a figure previously undreamt of and obtained by a comparatively small sacrifice in speed.

The Power Plant

The year has been marked by an ever-increasing use of air-cooled engines both for military and commercial airplanes. The air-cooled engine avoids the frequent troubles of the water-cooling system, is lighter in weight owing to its compact star-shaped arrangement, and has a further advantage in weight by reason of the fact that the radiator and water in the radiator and engine cylinders can be dispensed with. The somewhat greater head resistance due to the projecting cylinders is offset by the fact that

there is no radiator resistance to take into account, and by careful cowling and the covering of exposed parts such as overhead valve gear designers have found it possible to reduce the resistance of the air-cooled engine to a minimum. Air cooling is now so thoroughly understood that the compression ratios employed in this type of engine are equal to those of the water-cooled type.

In the air-cooled field the Wright J-4 and J-5 of something over 200 hp. are being used extensively for training planes both by the Army and Navy, taking the place of a very reliable water-cooled power plant. These engines are also rendering an excellent account of themselves in the hands of the commercial operators. Two radial air-cooled engines have been constructed in the 400-hp. field, the Wright "Simoon," a nine-cylinder engine rated at 350 hp. at 1900 r.p.m. and weighing only 640 lb., and the Pratt & Whitney "Wasp" rated at 400 hp. also at 1900 r.p.m. This latter engine has been extensively flight tested in three ships, the Wright "Apache," the Boeing fighter, and the Curtiss "Hawk." The results of these tests have shown that a plane with an air-cooled engine can readily out-perform its water-cooled competitor even when installed in ships not designed for its use. Two radial air-cooled engines in the 500 hp. class, the Wright P-2 and the Pratt & Whitney "Hornet," are in the development stage only, but with every promise of success.

There are also a number of small air-cooled engines coming on the market, such as the Wright-Morehouse, a two-cylinder 30-hp. engine; the Rickenbacker, a five-cylinder engine of approximately 60 hp., and one or two others. These small engines will play a useful part in the small commercial and sport type of plane.

The Fairchild-Caminez 150-hp. four-cylinder air-cooled type recently flight-tested is unique in that it dispenses with connecting rod and crank arm, the pistons working directly on a cam on the propeller shaft. Each cylinder completes four strokes and a working cycle in one revolution of the shaft, so that a high piston speed is advantageously combined with a low r.p.m. of the propeller in airplanes of medium speed.

In Europe enormous attention is being paid to the problem of securing the utmost reliability in aircraft engines and some very interesting results have been achieved. A number of flights have been carried out in the past year, such as those reported above by Alan Cobham and those made in Breguet planes by French aviators from Paris to points in Central Africa, Siberia (as far as Omsk), and Persia (Bender-Abbas and beyond) with practically no engine trouble to speak of. The "Napier-Lion V" engine is capable of developing on aviation gasoline 470 hp. for a dry weight of 940 lb. in regular operation. It has been found that it can be boosted up into a high-speed, short-life racing engine and develop 700 hp. for a dry weight of 700 lb. The "Lion V" engine, under the name of "Lioness," has been built to work in an inverted position, the purpose of this being to provide the pilot a better view. Secret tests on a very large scale are also being carried on with the supercharging of V, Vi and the "Lioness.' The supercharger used on the Lion engines is of the turbine type, working at an extremely high rate of speed, with the exhaust gases as the propelling medium.

In the water-cooled types attention has been concentrated on the 500-, 600-, and 700-hp. classes. In the first class is the Packard IA-1500 which is now being put into service by the Navy both in fighters and as a geared engine in the large twin-engined flying boats such as the PN-10. One of these engines has developed 600 hp. at 2500 r.p.m. during a continuous test of 50 hr., which is indeed a remarkable performance. The Curtiss Company has developed a remarkably light engine in the V-1400 which develops 700 hp. and is likely to give useful service in pursuit and racer planes, as in the Schneider Cup race. The large water-cooled engines are now showing a remarkable degree of endurance, and reports from the fleet indicate that they can be used for periods of 300 hr. between top overhauls.

In the power-plant-accessory field a number of interesting developments may be reported. Thus the Aeromarine Company has continued the construction of an inertia starter, in which a flywheel is set into very high speed of revolution by hand through the medium of gearing, and later communicates its kinetic energy to the engine for starting purposes. The B-G Company has recently brought out a midget plug which bids fair to take the place of the standard size.

AIRSHIPS

Undeterred by the terrible disaster to the *Shenandoah*, the Navy is investigating the possibility of building two airships each of over 6,000,000 cu. ft. capacity. The law of dimensions is all in favor of large airships, and it is expected in these huge craft to attain greater speed, reliability, and carrying capacity than ever before. Particularly for ocean traffic many authorities place strong hopes on the utilization of lighter-than-air craft because of their greater range and load-carrying qualities. One of the most encouraging features of the year in regard to American airship development has been the granting of a contract to the Airship Development Corporation of Detroit for the building of a metal-clad airship, in which the perishable rubberized-cotton outer covering is replaced by thin duralumin sheet only 0.008 in. in thickness, and the metal covering is itself designed to take its share of structural loads. While the design is only one of 200,000 cu. ft. and many difficulties are anticipated, the experiment is being watched with world-wide interest.

E. E. ALDRIN, *Chairman*

Measures to Be Observed in Cylinder Grinding

THE up-to-date grinding machine is equipped with many wonderful devices, but, unfortunately, none of them performs the thinking part of the business. The most important feature of the machine from the production engineer's point of view is a broad-faced wheel on a stiff spindle, with ample belt power behind it. Provision should be made for changing from a fast side feed for the first few roughing cuts with a reduced work speed, and as heavy a depth of cut as can be obtained, to a faster work speed with a slower side feed for the finishing cuts. A halt for wheel truing at the right time may also be made.

Almost a volume might be written on the question of finishing cylinder bores alone, since there are so many conflicting opinions and different methods in vogue. Cylinder bores are ground with a water jacket and without; with water running on the outside and the inside kept dry; with water flooding the inside, etc., while some are not ground at all, but are either finished with a single-point tool or by rolling the surface.

First of all it may be mentioned that the precaution of using water in grinding cylinders is a means of maintaining an equable temperature, although not by any means a normal temperature. This being so, it does not obviate unequal expansion resulting from faulty sectional design. Rolling the walls of the bore has as its main object the attainment of a high surface finish, but the practice is open to two objections. The first is that it may, if the metal be not truly homogeneous, upset the previous bore and leave a hole that is not truly cylindrical. The other objection applies to bores which are not truly cylindrical, in which case the hard rolled surface is an undesirable feature in the final running in. Long experience indicates that the ground cylinder bore gives the best results so long as the surface finish is of what might be termed an indifferent character as far as luster is concerned. That is, the grinding is done dry with a soft coarse wheel which does not unduly heat up the cylinder and which leaves a slight nap on the surface. This rapidly disappears on the test bench, and a good surface is obtained. Provided a hole is obtained which is truly cylindrical and parallel, it is not a serious matter if the walls of the cylinder bore have a surface that is somewhat woolly. The final finishing may be accelerated by spending a few seconds longer in cylinder grinding, using a slightly glazed but truly balanced wheel.

From the point of view of accuracy there can be no question but that grinding is superior to any other method for finishing cylinder bores. Where contrary opinion is held, those responsible would do well to pay more than superficial attention to excuses for failure of indifferent quality of work. (*The Automobile Engineer*, vol. 16, no. 217, July, 1926, p. 254.)

Modern Developments in Inspection Methods

A Description of the Ingenious Apparatus and Unique Methods by Means of Which Inspection Keeps Pace with Production at the Hawthorne Plant of the Western Electric Company

By E. D. HALL,[1] CHICAGO, ILL.

IN THE course of evolution toward better things it has become increasingly evident that fair dealing in business and the giving of honest values are things that pay the best dividends. Inspection as a distinct function in an organization is a natural outgrowth of this evolution, and is a comparatively recent development.

While maintenance of a standard of quality is the primary function of inspection, many by-products readily develop from it. Among these is knowledge, not obtainable by other means, which may result in improved methods of manufacture, reduced waste, lower costs, and more intelligent supervision.

Organization

A complete inspection organization should include the inspection of raw materials, parts in process, finished apparatus, tools, gages, and machinery, development and design of inspection equipment and gages, and methods, maintenance of inspection equipment, physical and chemical laboratories, analysis and planning, check inspection, and investigation of complaints.

Whether all of these functions are provided for, as well as the ways in which two or more of them are combined, will of course depend both upon the size and upon the requirements of an organization.

Place in Organization

Inspection in general does not create but rather controls quality. Quality is conceived in the design and given substance in the materials chosen and form in the manufacturing operations. Given good designs and materials, the Manufacturing Organization must be held responsible for the construction of a satisfactory commodity.

However, the executives of this branch have many opposing forces bringing pressure upon them, such as demands for quick delivery, low costs, high earnings for the operators, and quality. Since the first three are immediate and ever present, while the consequences of variations in quality are usually more remote, it follows that the first three will receive the most attention by the branch engaged in producing, and that the supervision and control of quality because of its importance can best be cared for in a separate organization.

For the same reasons the head of the inspection work should report directly to an executive who is far enough up the line to give due weight to quality as well as costs and production.

Standards and Specifications

In order that inspection may be uniform and effective, standards and specifications are needed. While it is essential that the product be kept up to the standard of quality, it is just as desirable that the cost of the product should not be increased by unnecessary refinements.

The fundamentals of good specifications are (1) a knowledge of the necessary requirements, properties, and allowable tolerances, and (2) a statement of the essential requirements in such a clear and concise manner that they may be determined with certainty and admit of but one interpretation.

It is a function of the Inspection Development Organization to analyze the specifications and devise methods and equipment that will enable the inspector to check the product to the specifications.

Tolerances

On a drawing a dimension is a constant and something definite, but when transferred to a piece of metal it is a variable, and even at best is more or less of an approximation.

It is impossible to make a quantity of parts exactly alike in all particulars, so in setting up standards some deviations must be allowed, and wherever these are of importance their nature and extent should be specified.

From one aspect, inspection work is the consideration of and decisions about variations and tolerances. To the uninitiated an inch is an inch and black is black, but to an inspector an inch is never exactly an inch but is always plus or minus something—and there are many kinds of black.

It is a large problem to establish in each particular case just how much an inch may vary more or less, and another big problem to determine just which of the parts under inspection are within the allowable limits and which are not, for gages cannot be made exactly to size. Some allowance, however, small, must be allowed in making them, and two or more gages of the same kind are never of exactly the same size. In use they wear, so another allowance must be made to determine when a gage must be repaired or discarded. Again, there are personal errors in using the gage, and finally there may be some elasticity or "give" to the part being gaged that makes possible a difference of opinion as to when the gage just fits.

Fig. 1 shows graphically the tolerances allowed in the manufacture of telephone multiple jacks and plugs, and in the gages for them. Each small space represents 0.0001 in. If the chart were not shortened it would be fifteen times as high.

It will be observed that there is an allowance of 0.0005 in. between the largest plug and the smallest jack.

A variation of 0.0001 in. is allowed in the manufacture of the gages as shown by the lines, and they are allowed to wear from 0.0001 in. to 0.0002 in. The shaded edges show the dimensions of the gages worn to the limit.

The gages are selected by the tool inspector for the Manufacturing and Inspection Departments. For instance, the new "not go" plug gage for the No. 92 jack is given to the inspector, and when worn to the limit for inspection work is reground and given to the assembly department. When again worn to the limit it is reground and given to the reaming department. The new "go" gage is given to the assembly department and when worn and reground to the inspectors, the object being that as the apparatus progresses through the manufacturing and inspection operations the gages used successively will become more tolerant, which will tend to compensate for errors of observation, thereby lessening the danger of disputes.

This practice of selecting gages so that the more stringent gage is applied first is quite general in our work wherever a particular dimension is gaged more than once.

All gages are checked periodically. The intervals allowed between checks are determined, largely from past experience, and depend upon the importance of the gaging operation, the amount of use, and the probable rate of wear. Some gages are checked daily, a few twice a day, but the intervals for the major portion vary from a week to three or four months. The total number in use is over 25,000. A complete card file is used to control the time for checking and to keep a record of the results of checks, calibrations, and repairs.

In most instances the determination of tolerances must be a compromise between the cost of manufacturing the parts and the requirements imposed by the performance desired, by the interchangeability of parts, and by the cost of assembly.

The three factors: requirements of operation of the finished product, materials, and methods of manufacture, are all more or less variable, but are mutually related so that narrow tolerances on one may be had only at the expense of the allowable limits remaining available for the others.

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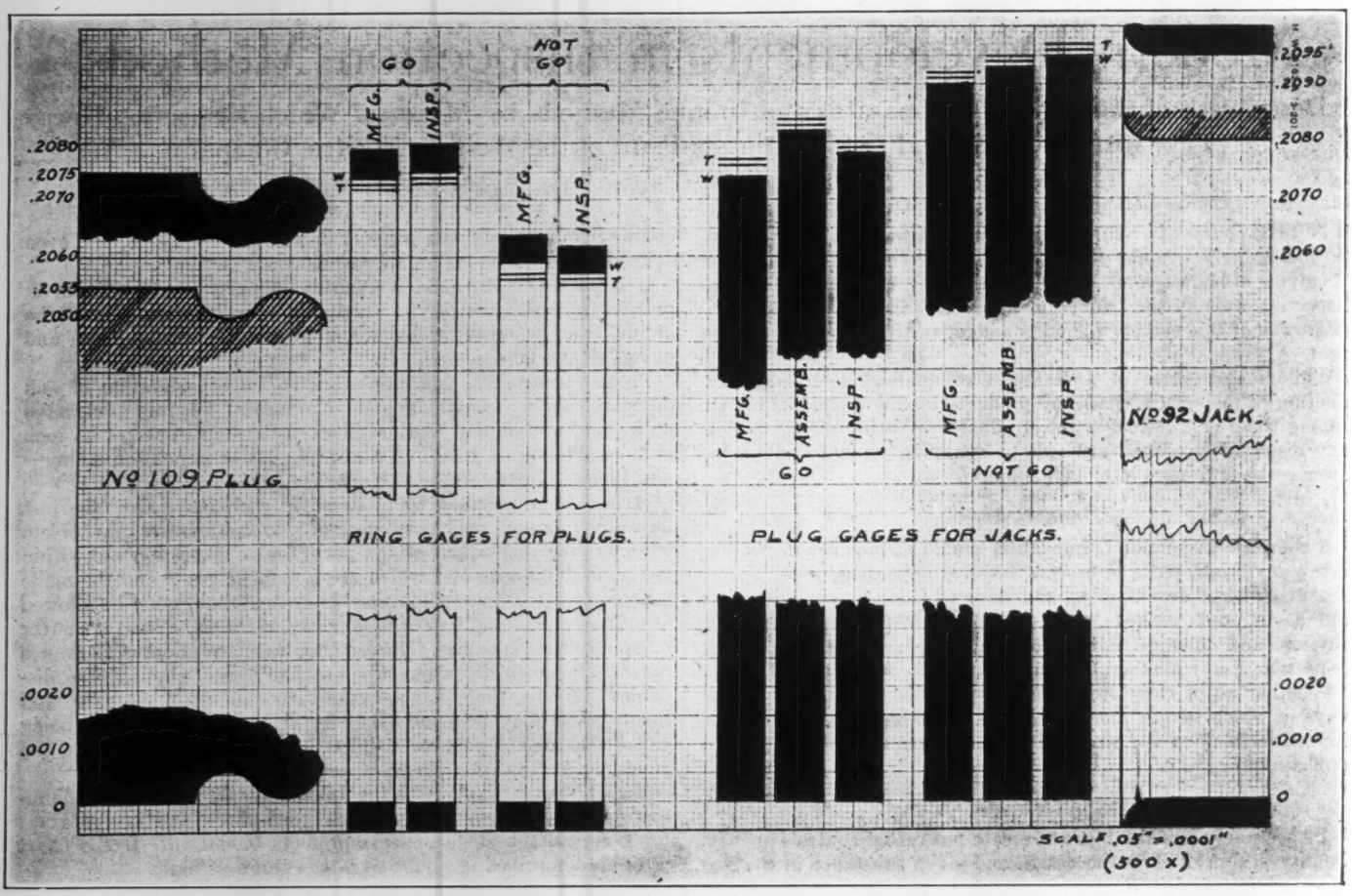


FIG. 1 TOLERANCES ALLOWED IN MANUFACTURE OF TELEPHONE MULTIPLE JACKS AND PLUGS, AND IN THE GAGES FOR THEM

METHODS AND EQUIPMENT

One of the most striking phases in the evolution of inspection work is the development of equipment and methods whereby unskilled and semi-skilled people are able to make intricate and difficult physical measurements and tests with a relatively high degree of precision. It is the adaptation of laboratory methods and laboratory apparatus to ordinary shop conditions. Not only is high-class work of this kind carried on as a routine process, but the rate of production is far greater than would be expected by one acquainted only with the technical or scientific side of it.

Such tests cover all kinds of physical quantities, the measurement of the thickness of mica sheets to the ten-thousandth of an inch, capacity of condensers to a few microfarads, intervals of time to thousandths of a second, and inductance and effective resistance to $^1/_{10}$ per cent.

Fig. 2 shows an indicating gage used to measure and sort sheets of mica, indicating the thickness in steps of 0.0001 in. A ten-thousandth of an inch gives a $^1/_{32}$-in. movement of the indicator on the scale.

This type of gage is made in many forms and adapted to measure a great variety of dimensions. It is frequently used as a limit gage with electrical contacts instead of a scale. The details of construction are shown in Fig. 3. The plunger *B* operates in the body *A*, actuating the multiplying levers *C* and *D*. The lower end of *D* is shaped into a pointer and indicates the size gaged on the scale *E*. A_1 is an adapter and is varied to suit the piece being gaged, as is also the end of *B*.

FIG. 2 INDICATING GAGE USED TO MEASURE AND SORT MICA SHEETS

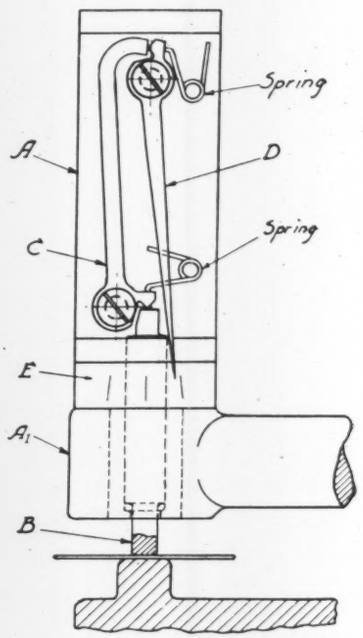


FIG. 3 GAGE FOR MEASURING THICKNESS OF SHEETS

Fig. 4 illustrates another adaptation of the same type of gage. The part gaged (shown on top of the gage box) is a strip of brass having 100 rectangular slots 0.040 in. × $^1/_4$ in. at intervals of $^1/_8$ in., each slot to be within ±0.003 in. of its theoretical location from a 0.067-in. hole at one end of the strip. The slots are gaged ten at a time, the strip being moved along and indexed by the lever at the right, and slots that are outside the limits are indicated by the lighting of small lamp shown just above the gage heads. A very accurate master for checking the gage is shown above the strip that is gaged.

Incidentally, it may be mentioned that the perforating operation relieves the internal strains and causes the parts to shrink. The

shrinkage is not uniform and the tools must be much more precise than is indicated by the tolerance of ±0.003 in. for the finished part.

Simplified testing methods are absolutely essential if apparatus having precise requirements is to be built in quantities at a low cost.

For making some of our tests, if made in the ordinary way, there are not enough people of the proper caliber available to handle the output desired, and if available the cost of the product would be so increased as to reduce the economic usefulness.

The design should be made to permit, as much as possible, simplified manufacturing, inspection, and installation methods. Operations are planned, and machines, equipment, and apparatus provided so that they may be performed with as little preliminary training as possible on the part of the operator; that is, the technical ability is concentrated upon planning, supervision, and development, while the mass of the work is reduced as far as possible to routine.

In the company with which the author is connected the physical laboratory maintains the primary standards of the organization by frequent comparisons and calibrations at the Bureau of Standards and with certain basic standards maintained by the Bell Telephone Laboratories. It also calibrates and checks at regular intervals the secondary standards and equipment used in the manufacturing and routine inspection operations.

Besides the maintenance of standards and calibration work,

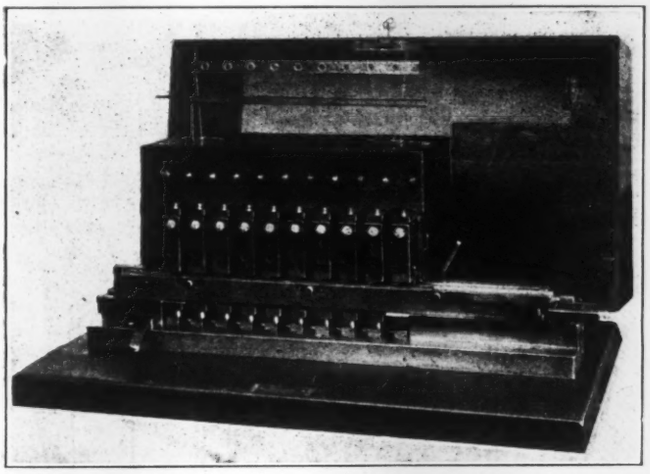


FIG. 4 DEVICE FOR GAGING SLOTTED STRIPS

there are numerous tests that, because of their nature or because of the relatively small number of each kind, can be handled only in a laboratory by expert technicians.

In Fig. 5 is shown an Amsler standardization box being used to test a 10,000-lb. testing machine for tensile pull. By changing the end pieces it is adapted for testing compression. It consists of a steel cylinder having a small cylinder with a micrometer-controlled piston on one side and glass tube with a bulb at the end on the other. The cylinders and part of the glass tube are filled with liquid and the piston adjusted to bring the liquid to a mark on the tube. When tension or compression is applied to the tube the micrometer screw is adjusted till the liquid is again brought to the mark, and by means of the change of reading of the micrometer and a calibration chart the amount of force applied by the machine is checked.

Fig. 6 shows a Schopper testing machine measuring the elongation and tensile strength of sheet duraluminum 0.002 in. thick. The scale on the lower arc indicates the load applied, and the scale on the smaller arc the percentage of elongation.

A test devised by the Bell Telephone Laboratories to check and calibrate a number of Rockwell hardness-testing machines is illustrated in Fig. 7. Where the indications of these machines are used as a part of raw-material specifications, it is desirable that the readings of the testing machine of the supplier and of that of the purchaser be the same, and to accomplish this the effective weights applied must be adjusted to be of very nearly the same

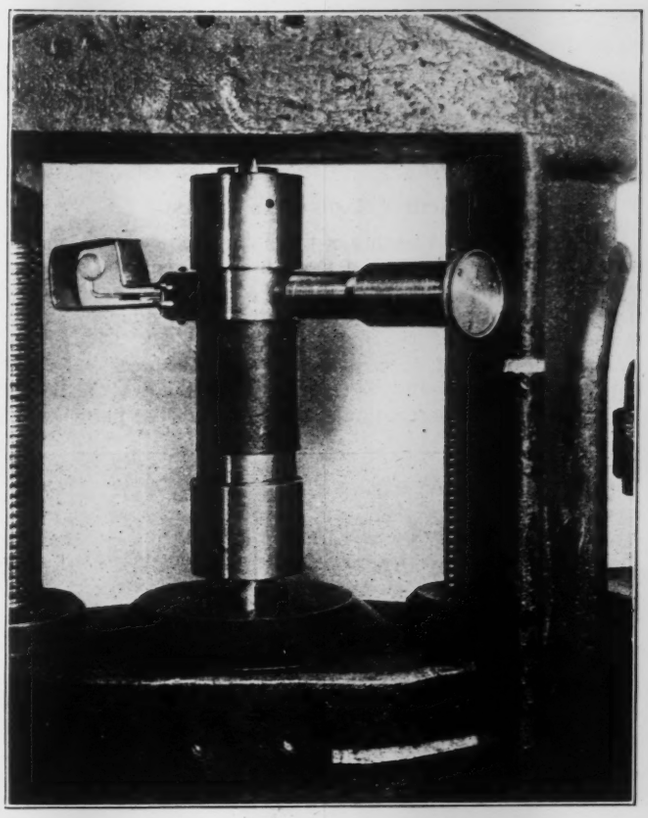


FIG. 5 AMSLER STANDARDIZATION BOX BEING USED TO TEST A 10,000-LB. TESTING MACHINE FOR TENSILE PULL

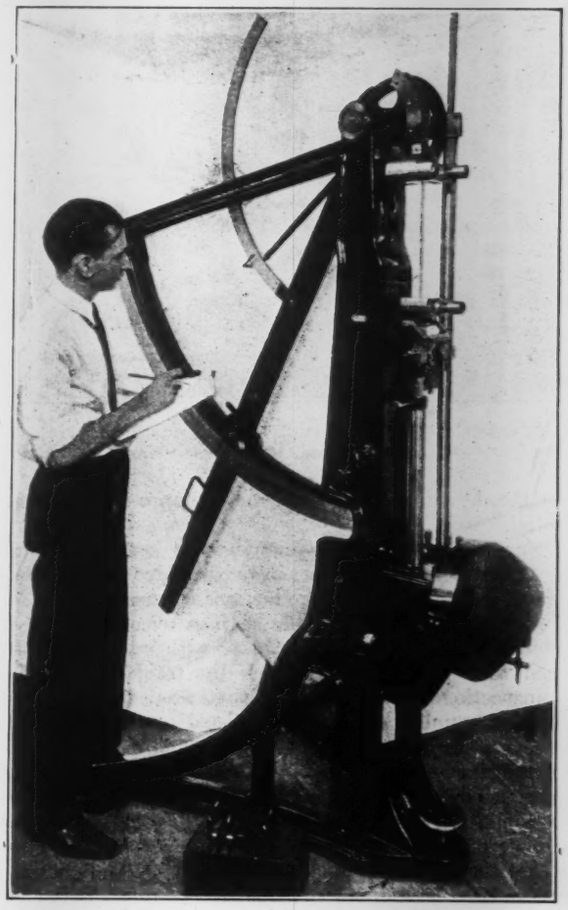


FIG. 6 SCHOPPER TESTING MACHINE MEASURING THE ELONGATION AND TENSILE STRENGTH OF SHEET DURALUMIN 0.002 IN. THICK

value. There are several ways this might be accomplished, but the method shown is very convenient and, if the testing machine is in good adjustment, very accurate. The Rockwell is clamped to the moving head of a standard Olsen testing machine, and the pressure exerted by the ball of the hardness tester is measured on the weighing beam of the Olsen machine by carefully balancing one against the other.

MACHINE GAGING AND TESTING

Machine gaging and testing of parts may become an economical method when the quantity of parts produced is sufficiently large or when the gaging operation involves a tiresome amount of work, such as the continual lifting of weights as in testing solder joints or brazes.

As the design and construction of such machines is generally quite costly, a careful study of the relative economies of the methods, the probability of the continued production of the parts, and the

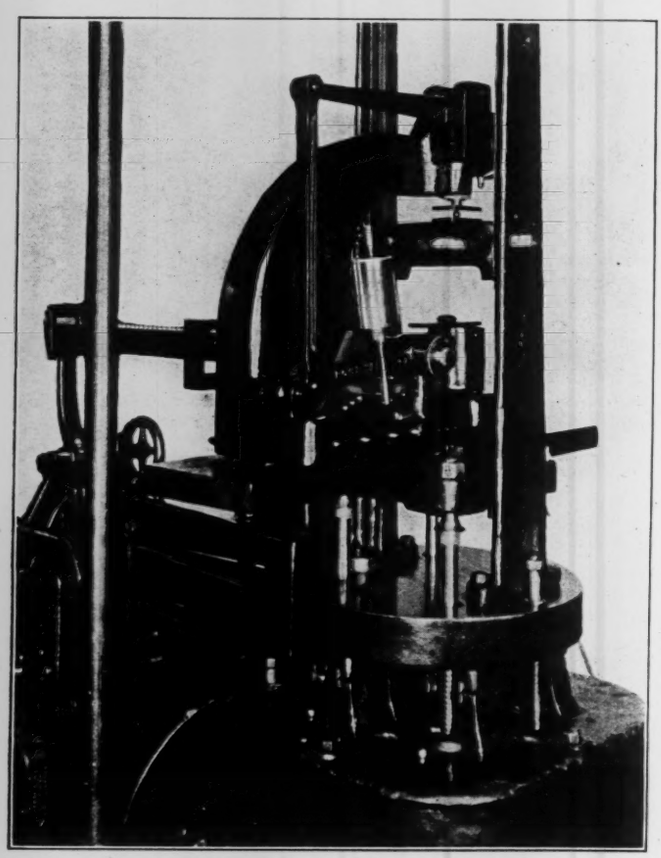


FIG. 7 METHOD OF CHECKING AND CALIBRATING ROCKWELL HARDNESS-TESTING MACHINES

costs of the design, building, and maintenance of the equipment, is essential.

In order to justify such equipment we generally expect the resultant savings to pay the cost in two or three years at the most. The uncertainties of future production are usually too great to extend the time for realizing the savings over a greater period.

Machine inspection operations may, with advantage, often be combined with visual inspection. If the total time required for visual inspection is greater than that needed by the machine for a certain number of parts, the visual operations are divided among several inspectors who may be rotated on the work. This latter arrangement reduces the fatigue, and the work of the group is not so much disturbed by the absence of one member.

In a combination such as this it is advantageous to arrange the number of inspectors and the operations performed by each one so that the machine acts as a pace setter.

An automatic hopper-fed machine for testing tubular fuses is shown in Figs. 8 and 9. The machine tests for electrical continuity and minimum length dimension, and distributes the fuses to four girls for visual inspection, thereby setting the pace for this operation.

The fuses are carried by the chain conveyor *B* (see Fig. 9) in the direction indicated, past the hinged contact member *C*. Normally *C* is held against stop *D* by the action of spring *E*. If the fuse wire and terminals are continuous electrically and the length of the fuse is correct, the control circuit is closed through contacts *F* and *G* and the fuse is accepted.

If the contacts *F* and *G* remain open because the fuse is undersize or if the fuse is "open" electrically, the control circuit remains

FIG. 8 AUTOMATIC HOPPER-FED MACHINE FOR TESTING TUBULAR FUSES

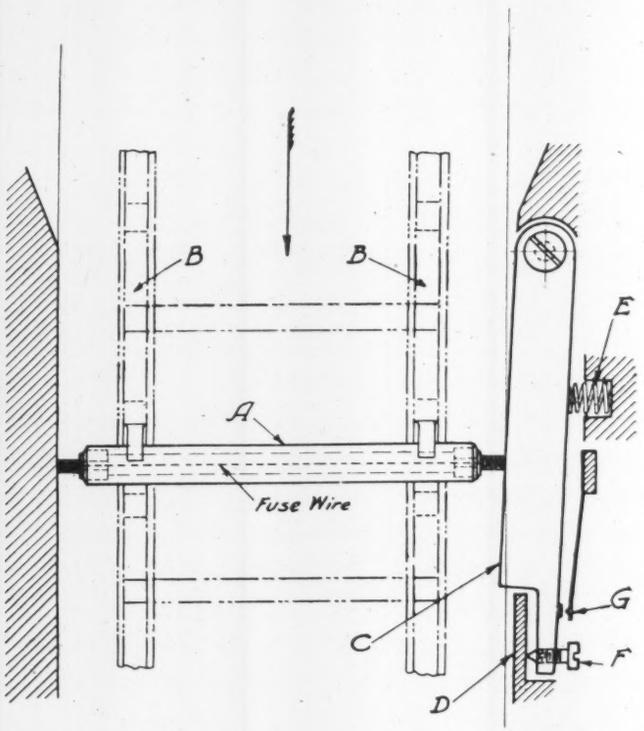


FIG. 9 METHOD USED IN AUTOMATIC INSPECTION OF FUSES FOR LENGTH AND ELECTRICAL CONTINUITY

inoperative and the fuse is rejected. Any failure in the current supply would result in the rejection of all fuses rather than in the acceptance of defective ones. The accepted fuses are carried by a belt conveyor and distributed to the four inspectors as shown in Fig. 8.

The savings from machine testing and gaging over manual methods are $4500 per year on a production of 6,500,000 fuses. The pace-setting feature increases the savings by about the same amount.

To some it may seem that pace setting might be detrimental to the quality of the work, but if properly carried out it is generally beneficial. An inspector who is working along at a slow rate is

apt to have his attention distracted by any number of surrounding circumstances, which is certainly detrimental to the work, while it is found that one who is comfortably busy pays much closer attention to the work, resulting in a better product, and is less fatigued.

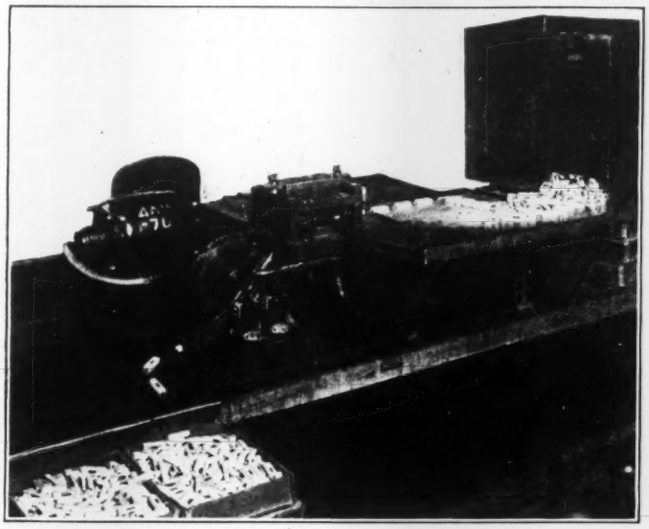
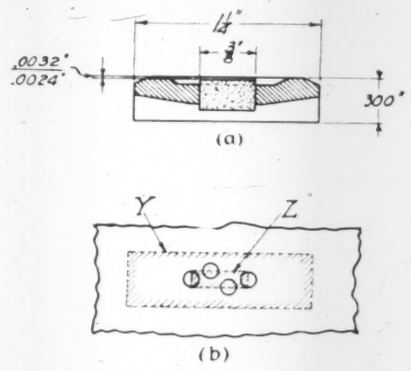


FIG. 10 VIEW OF MACHINE FOR GAGING CARBON INSERTS IN PORCELAIN BLOCKS



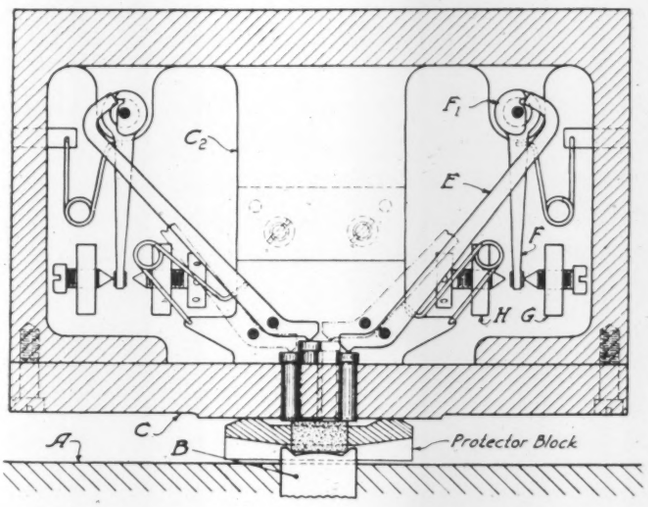


FIG. 11 GAGE FOR MEASURING UNDER-FLUSH DIMENSION OF CARBON INSERT IN PORCELAIN BLOCK

Parts of the apparatus used in protecting telephone equipment against the effects of high voltages are a block of carbon $1^1/_4$ in. $\times$ $^3/_8$ in. $\times$ 0.155 in. (*a* and *b*, Fig. 13) and a porcelain block $1^1/_4$ in. $\times$ $^3/_8$ in. having a recessed surface into the center of which is inserted a small carbon block 0.370 in. $\times$ 0.110 in. shown in Fig. 10.

The surface of the carbon insert is under-flush with the rim of the porcelain block. Fig. 10 is a general view of the machine and Fig. 11 a sketch of the gaging head for measuring the under-flush dimension which must be maximum 0.0032 in.—minimum 0.0024 in. for at least half of the area of the carbon insert (see *b*, Fig. 11). The porcelain blocks are fed to the gage by a chain conveyor (Fig. 10). An elevator *B* (Fig. 11) presses the block against gage surface *C*. Four plungers mounted in body *C* are applied to the surface of the carbon insert as shown at *b*, Fig. 11. Each plunger by means of multiplying levers, *E*. F_1, and *F*, and springs, places a contact arm in one of three positions: in contact with

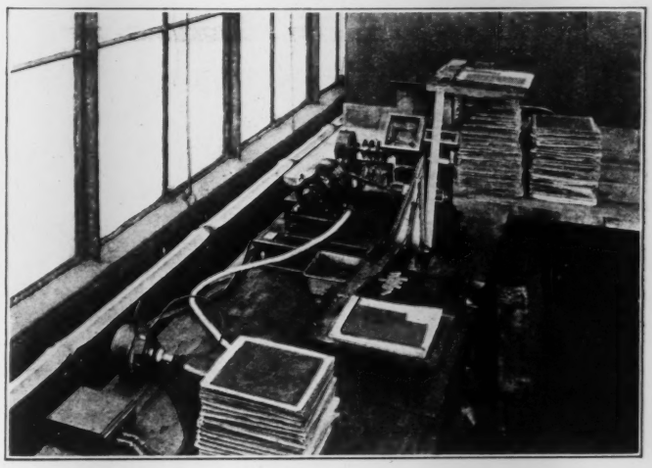


FIG. 12 MACHINE FOR GAGING PLANENESS OF CARBON BLOCKS

G or *H* or open. These contacts control the action of a number of relays so connected that when any three or all four plungers are within the limits the block is accepted. Otherwise a trap is opened in the exit chute and the block is rejected. The gage is adjusted to accept blocks in which the distance between surfaces is between 0.0024 in. and 0.0032 in., and reject if the distance is 0.0023 in. or less, or 0.0033 in. or more.

The machine, while hand-fed, is otherwise automatic in its action, gaging the parts at the rate of 2800 per hour, the rate for hand gaging being 990 per hour. The machine gaging is much more consistent than hand gaging and the maintenance cost much less. The machine will soon be associated with a series of other operations and fed automatically.

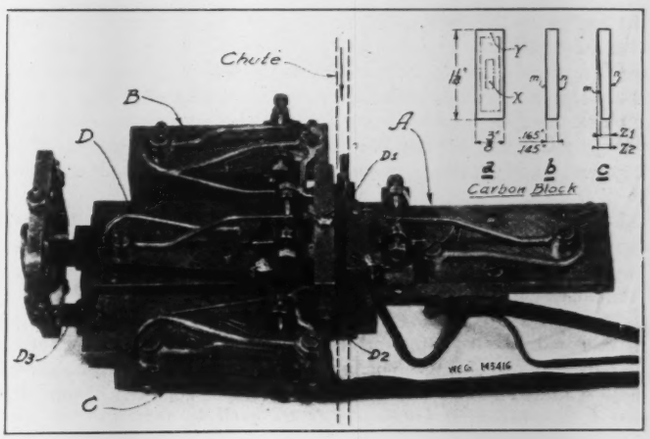


FIG. 13 GAGING HEAD OF MACHINE SHOWN IN FIG. 12

The annual saving is approximately $2500, based on a production of 4,500,000 parts.

The carbon blocks mentioned above (*a* and *b*, Fig. 13) are gaged for the planeness of each of the two larger surfaces and for thickness, in the machine shown in Fig. 12. The gaging head is shown separately in Fig. 13. The faces *m* and *n* need not be parallel, but the thickness must be within the limits Z_1 and Z_2 (*c*, Fig. 13).

It is important that the plane of area marked x (a, Fig. 13), which in use will be opposite the carbon insert of the porcelain block, shall be within one-half of one-thousandth inch (0.0005 in.) of the plane of the area y on both faces m and n. The area y is that on which the rim of the porcelain block will rest.

The carbon blocks are hand-fed into a chute and slide into the gage on edge, being properly located in the gage by a spring device not shown. The gages A, B, C, and D are similar to ones previously described. Gages A, B, and C are fixed with relation

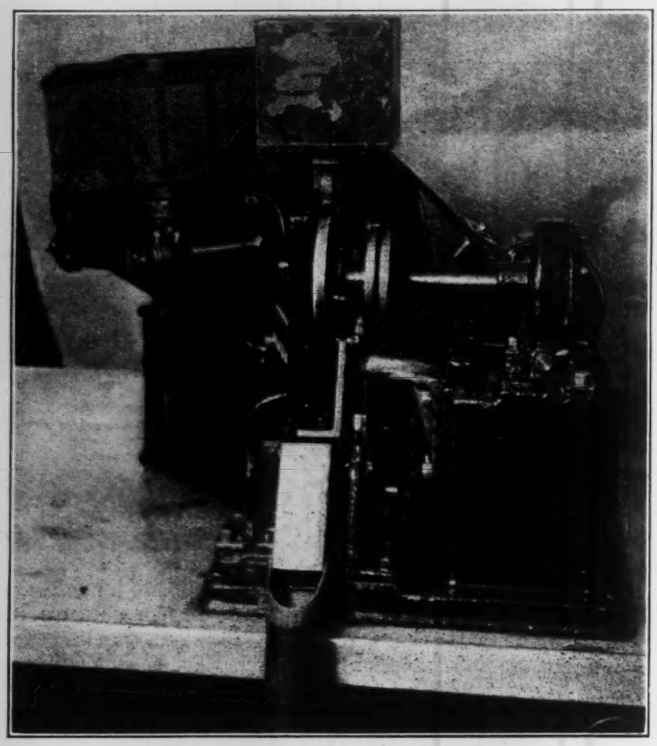


FIG. 14 MACHINE FOR TESTING MULTIPLE-SWITCHBOARD PLUG

to the chute, while gage D is mounted on a gimbal ring (pivoted at D_1 and D_2) which in turn is carried on a slide D_3 placed at right angles to the chute. Slide D_3 opens to permit the entrance of the carbon block and in closing presses the block by means of gage D against gage A, the former compensating for any variations in parallelism of the opposite faces. The thickness of the ends of the block are measured by gages B and C from anvils on D (hidden by the gimbal ring). The planeness of either face is measured by the gages A and D, the plungers of which cover the area x on either side of the block.

The electrical contacts shown on the gages operate, through relays, the control circuits that set the switches in the chutes (shown in Fig. 12) and sort the carbon blocks in "accepts" or one of the three classes of "rejects."

In Fig. 15 at (a) is shown a part used in the construction of the multiple-switchboard plug and in Fig. 14 the machine for testing it. The part is made of a piece of brass tubing $^5/_{32}$ in. $\times$ $1^1/_2$ in. having a plug soldered in one end and a short sleeve soldered around the other. The machine applies a 50-lb. weight test to the two soldered joints X and Y at the same time at the rate of 2900 per hour, the manual rate being 1050 per hour. On a production of 2,500,000 pieces per year the saving is approximately $1200. However, the more important consideration is the elimination of a tiresome and monotonous operation.

The pieces to be tested are hopper-fed to chute A (Fig. 15) which supplies the parts to notches in the intermittently revolving turret B mounted on the anvil C. The plunger D is attached to slide D_1, which is moved in frame C_1 by means of cam E and roller D_2. C_2 is an additional guide for the plunger D.

After the turret has carried the part to the testing position and stopped, plunger D enters the sleeve, gradually applying the testing load (furnished by weight D_3) to the soldered joints Y and X. If the soldering is good the load is supported by the piece for a short time, after which the cam raises the weight, the turret turns, and the piece is discharged into the "O.K." chute.

If either joint is weak the weight and slide will not be supported but will drop down to the limit allowed by the cam as at E_1. This permits a wedge-shaped piece D_4 mounted on slide D_1 to push the far side of lever F (pivoted at C_3 on base C_4) to the right. The near side at F is pushed into grove B_1, and when the turret turns the defective piece is ejected. Lever F is reset by a cam-operated device after each rejection.

A small drawn nickel-silver sleeve with tang attached, used in multiple jacks, is gaged for several dimensions in the machine shown in Fig. 16, and the defective ones are sorted into separate containers. This machine is hand-fed, and with a production of 6,000,000 per year the saving over a hand-gaging method is $800 and with a production of 12,000,000 the saving is $5000.

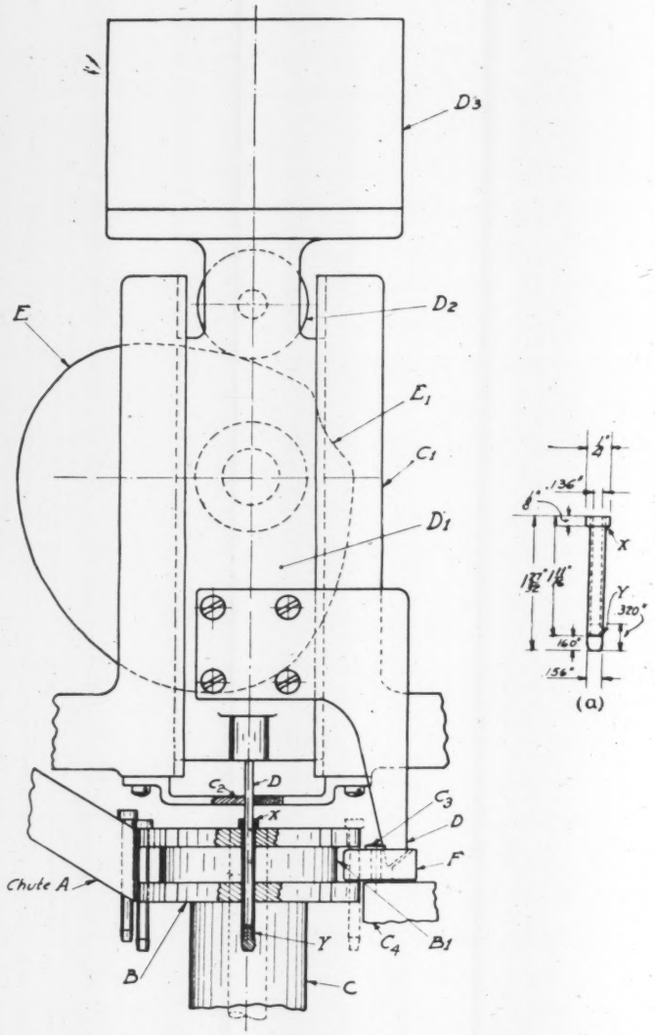


FIG. 15 METHOD OF AUTOMATICALLY TESTING SOLDERED JOINTS ON PLUG SHELLS

In such operations as plug gaging there is a distinct advantage in the machine method since the machine may be made to work uniformly, applying the same pressure in the same way each time, thus removing errors caused by variations in the "feel" or judgment of inspectors.

Fig. 17 shows at (a) a heat coil used to protect telephone equipment from an excessively heavy electric current, and Fig. 18 is a view of an automatic machine for testing it. The machine tests for high and low electrical resistance, gages length of pin X, length of sleeve Y, and tests the strength of a soldered joint. The rejections for the various defects are sorted into the boxes shown below the bench.

The chain elevator takes them from the hopper to the belt A

(Fig. 18), which carries them endwise to the chute B. A tripping device in the chute at C reverses the coils that have the wrong end down. From the chute they enter the vertical magazine D and from there are fed to the holding fixtures which are mounted on an intermittently rotating turret.

Referring to Fig. 17, which shows the gage for length of pin

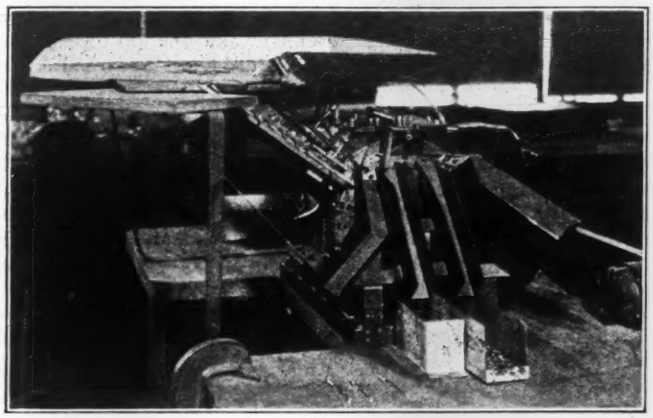
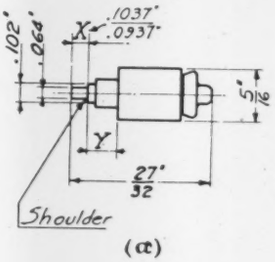


FIG. 16 MACHINE FOR GAGING NICKEL-SILVER SLEEVES USED IN MULTIPLE JACKS AND FOR SORTING OUT DEFECTIVE ONES

X and also tests the strength of a soldered joint between pin X and sleeve Y, A is the body carrying two sliding members B and C. B carries the gaging mechanism and electrical contacts. B_6 is a preliminary centering guide for the heat coil. Centering slides D, D carried in B are normally held open by springs (not shown). A is normally lifted in C by springs A_3 and A_4. Slide B is normally held down on A by means of spring A_1.

As the entire gage (A, B, C, D) descends, the heat coil is centered approximately by B_6. Then slide C is restrained by an anvil E, and as A continues downward the slides D, D are closed by the beveled surfaces C_1D_1 and C_2D_2, thereby centering coil and providing the gaging surface for the shoulder formed by the sleeve. As A continues downward the gaging surfaces on D, D engage the shoulder and the pressure for operating the gage mechanism is transmitted from A to B through spring A_1, which limits the testing pressure applied to the soldered joint.



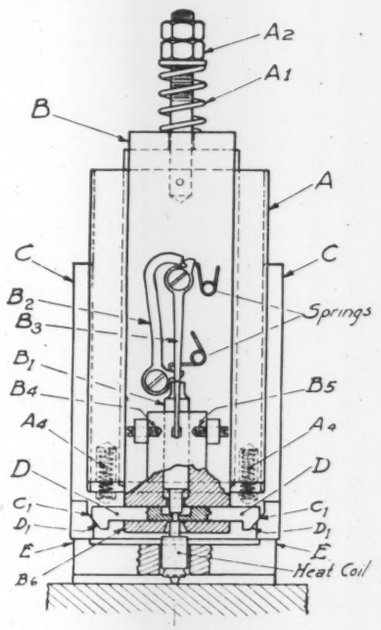


FIG. 17 GAGE FOR CHECKING PIN LENGTH IN AUTOMATIC INSPECTION OF HEAT COILS USED IN PROTECTION OF TELEPHONE EQUIPMENT

If the length of pin is within limits the electrical circuit remains open and the coil passes on to the next test. If too short the circuit is closed through lever B_3 coming in contact with B_4, and if too long B_3 makes contact with B_5, rejecting the coil into the proper container in either instance.

A similar operation gages for the sleeve length Y.

The machine tests 5,000,000 coils per year, effecting a saving of about $5000 over the hand method.

OPTICAL METHODS

Optical methods offer attractive ways of making many inspection tests and measurements. The size and form of irregularly shaped cams, gear teeth, and dies are readily determined in this way. Fig. 19 shows the projected image of the meshing of a pair of small gears. For inspection they are placed on mandrels spaced

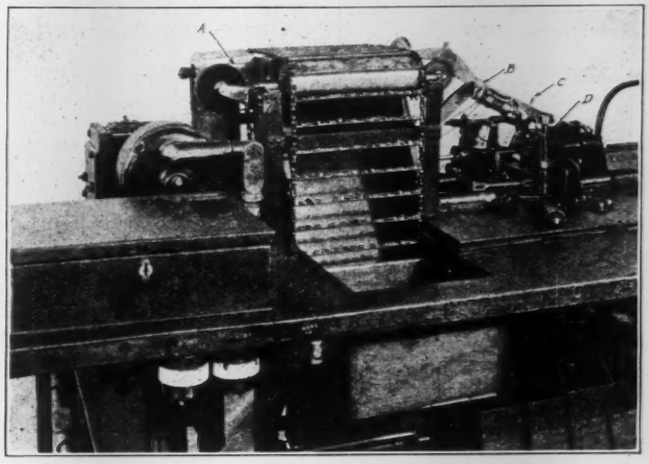


FIG. 18 AUTOMATIC MACHINE FOR TESTING HEAT COILS

FIG. 19 OPTICAL INSPECTION—PROJECTED IMAGE OF MESHING OF A PAIR OF SMALL GEARS

the same distance apart as the shafts on which the gears will be assembled.

The reduction of diameter of a tensile-strength test piece is difficult to measure with calipers when the diameter is small (Fig. 20), but the amount of reduction is shown readily by an enlarged projection.

The sizes of the wires and mesh of standard sieves are not readily

measured by ordinary means (Fig. 21), but by the use of an enlarged image projected on a screen the measurements are readily made.

There are various measurements made where the quantity measured is small or the precision so great that results can best be indicated by a beam of light. It is only recently that satisfactory apparatus has been available for transforming light signals into sound signals and mechanical control. This is the photoelectric cell, which is a highly evacuated vacuum tube having two electrical conductors enclosed, one of which is metallic sodium, potassium,

FIG. 20 REDUCTION OF DIAMETER OF TENSILE TEST PIECE AS SHOWN BY ENLARGED PROJECTION

or calcium. When connected across a source of electric current it has the property of allowing more current to flow when a beam of light strikes it than when it is dark. It may be used in connection with an amplifier, similar to a radio amplifier, which magnifies the effect of the photoelectric cell so that it may be made to operate buzzers and relays, and through the relays, valves, motors, or other controlling equipment.

PARTS IN PROCESS OF MANUFACTURE

The reasons for inspecting parts in process are:

1 To prevent loss that would be incurred in further work on parts that are defective.

2 To control manufacturing processes and discover troubles before many defective parts have been made.

3 To make necessary tests and measurements that cannot be made conveniently, or at all, in the finished product.

4 To control piece-work operations and payments.

The most direct economies result from inspection when used as a preventive measure in controlling and correcting manufacturing processes and methods.

To this end the several branches of inspection work must be very closely correlated so that conditions observed in one place but affecting the work in another may receive proper consideration and be used to advantage.

STATISTICAL ASPECTS OF INSPECTION

Inspection work probably never will be reduced to an exact science, but it is remarkable how extensively scientific and mathematical principles can be used to improve and cheapen inspection processes. Offhand it would seem obvious that the most accurate estimate of the quality of any given material can be obtained by an inspection of every piece. However, our experience has indicated that this is not always the case and that frequently the results of a partial inspection are just as reliable as those of a complete inspection. One reason for this is that a complete inspection sometimes involves tedious and tiresome work which causes the inspector's interest and physical ability to do the job to lag, while a spot inspection, being less tedious, will be apt to be more carefully done.

In determining the percentage of a product that is to be inspected, where a spot inspection is used, it is necessary to have a fairly good working knowledge of the mathematics involved as well as of the manufacturing operations, since the precision of results is largely dependent upon the size of a sample and the way it is selected.

Another question that might be considered under the heading of the scientific or mathematical side of inspection is that of how inspections shall be made, that is, by attributes or by variables. That is, shall inspection be made merely to see that the material is within the requirements, or to see how far within the requirements the material lies, and whether the quality is deteriorating or not.

CHECK INSPECTION

In the factory with which the author is associated it is required that all material on its way from the manufacturing department to the place of storage shall pass through the hands of check in-

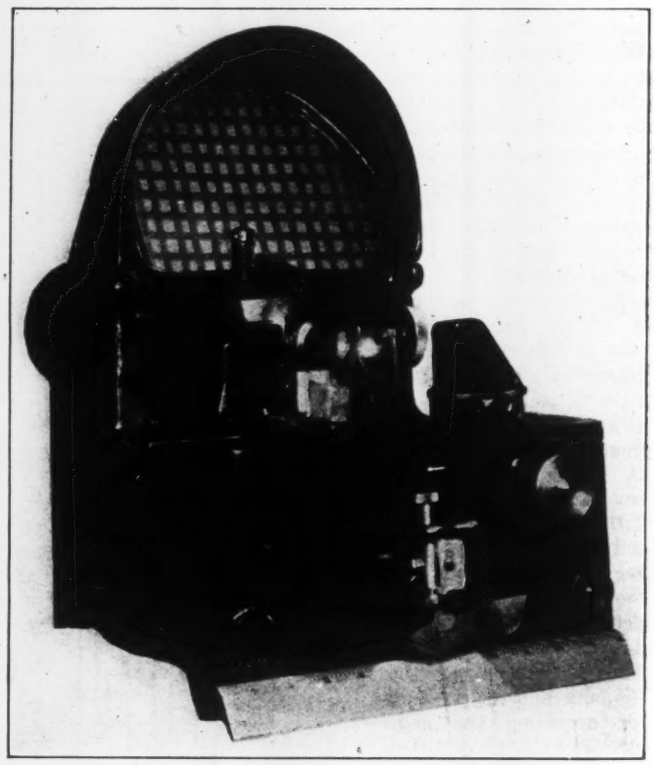


FIG. 21 ENLARGED IMAGE OF MESH OF SIEVE

spectors. These employees have laid out for them a certain percentage of each kind of product that they are to hold for inspection, and the samples that they take are selected at random throughout the shipments so as to represent the whole output. The approximate number of pieces of any type of apparatus that will be manufactured during a month is known in advance, and from that number, together with a knowledge of the precision of results desired, can be determined with a fair degree of accuracy the number of samples that must be inspected. A product that is made in quantities of 500,000 per month can be checked with a fair degree of accuracy by the inspection of four or five thousand pieces, while in some of our products, which run as low as 150 to 200 units

per month, the check inspection runs as high as ten per cent.

The results of check inspection can be used quite successfully in at least two directions. In the first place, they furnish a running picture of the general quality of manufactured product, and, in addition, if the results are immediately furnished to the Operating Department of the factory, they will enable the management to eliminate defects in material still in process of manufacture.

In our factories the check inspector is expected to look at material from the viewpoint of the customer rather than of the manufacturer. By that is meant that instead of considering the difficulty involved in overcoming defects, he thinks of the defect in terms of the trouble that it may cause in the customer's plant. In some cases instead of inspection for specific values set up in specifications, just as good or a better idea of the overall quality can be obtained by inspection on the basis of performance.

As a method of determining what might be called the index figure for normal quality, we have determined from records about how many of any certain defect may be expected to exist per 100 or per 1000 pieces. With the ratio of the number of that type of defect to the number that is expected in a normal product, an index number may be arrived at, and a combination of such figures for all of the various defects found in any given month will furnish an index number for the entire factory output. A scheme of this kind to be of any value requires a great deal of work, but fortunately after the base-period figures have been arrived at, the month-to-month analysis of results is comparatively simple and the index figures thereby produced furnish a very satisfactory way of keeping track of the general quality.

In order that the index numbers may be used to cover the entire product of the factory, it is necessary to bear in mind that the large and expensive types will have more influence on the final result than those which are cheaper and easier to produce. In order to take care of this feature each type of apparatus has been considered in accordance with its cost or selling price, which ordinarily is a fair criterion of the amount of work that has been done upon it.

The Year's Progress in Ferrous Metallurgy

IN THE summer of 1925 a series of articles were printed in MECHANICAL ENGINEERING entitled, Principles of Metallurgy of Ferrous Metals for Mechanical Engineers. These articles were collected and published in book form in January of this year, a second edition following in July. The present article is an attempt to present briefly such advances in the metallurgy of ferrous materials as have taken place since the publication of the above-mentioned series. It should be clearly understood, however, that no attempt is made to present the trend of progress in the metallurgy of ferrous materials generally, but only to report on that part of the progress which may be of interest to mechanical engineers.

MARTENSITE

The structure of martensite cannot be considered to be definitely established as yet. In this connection an interesting paper has been published by Hanemann and Schrader,[1] which originally appeared in German.[2]

In this paper the authors first present a review of previous investigations regarding the structure of martensite and austenite in hardened steels, their thermal expansion, and critical points. The current opinion based upon these investigations is that martensite is alpha iron whose space lattice has been strained by an unstable solution of carbon within the lattice. The authors point out that the established facts of the austenite-martensite reaction cannot be reconciled with the alpha-iron hypothesis of martensite formation called the "epsilon-eta hypothesis." They conclude from their investigations that when austenite changes to martensite in quenched steel there is a change in the carbon content of the austenite and the martensite. They claim that besidesaus tenite and ordinary ferrite, two formations, epsilon and eta, are found in quenched steel, and that these two are in metastable equilibrium with the austenite. The martensite contains less carbon than the austenite, with which it is in contact. A constitution diagram showing the lines of the metastable martensite system is given. According to the authors' hypothesis of the martensite system there is a transformation in pure iron at a certain temperature. By experiments, this temperature was found to be 685 deg. cent. In performing these experiments small pieces of soft Krupp iron containing 0.07 per cent carbon were used, and an electrocardiograph used for recording the thermal changes. A description of 71 photomicrographs is included.

It is important to remember, however, that the constitutional diagram given in the above paper in showing a metastable martensite system applies only to iron-carbon alloys which are low in manganese. The relative positions of the cementite and martensitic system might be shifted in special steels.

[1] Transactions of the American Society for Steel Treating, vol. 9, no. 2, Feb., 1926, pp. 169–233, including bibliography; discussion pp. 233–239 and 364.

[2] See reference 1 on page 28 of Metallurgy of Ferrous Metals, 2nd edition.

DELTA IRON

Reference has been made[3] to the fact that when austenite is heated through the uppermost critical point it undergoes a modification designated as "delta iron," and that this modification, like alpha iron, is body-centered. This has been confirmed by E. C. Bain's work on the nature of the alloys of iron and chromium,[4] Bain having found that it is possible to develop and preserve delta-iron solid solutions at room temperatures. In this case chrome-iron alloys are used. They are heated above the range for austenite formation; upon quenching in water the transformation to austenite is suppressed and the delta-iron solid solution is preserved engaged in a permanently stable form identical with alpha-iron solid solution.

The solid solutions of chromium in iron containing less than about 14 per cent chromium exhibit the alpha-gamma and gamma-alpha transformations upon heating. The temperature for the alpha-gamma transition is raised with increasing chromium content, while the gamma-delta change takes place at a lower and lower temperature as the chromium proportion is increased. The temperature range for gamma-iron stability therefore becomes narrow above about 10 per cent chromium, and gamma iron is not formed at any temperature in the alloys having much more than 14 per cent chromium except as influenced by carbon. In alloys richer in chromium, alpha- and delta-iron solid solutions are continuous and are physically identical. By quenching, delta-iron solid solutions have been preserved permanently stable at room temperature.

The carbon which is usually present in any alloy of this type acts primarily to enlarge the region of austenite formation—raising the gamma-delta temperature and lowering the alpha-gamma temperature. Furthermore, carbon extends the region of gamma-iron formation into the richer chromium alloys. Carbon when present in as large an amount as 0.35 per cent produces some gamma iron, even in alloys containing 30 per cent chromium.

Both chromium and carbon render austenite more sluggish and reluctant to transform into alpha iron (martensite) upon cooling. About 12 per cent chromium is required to preserve any appreciable austenite at room temperature after a water quench, even with the carbon as high as 0.35 per cent.

Among the observations made during this study was that of the high solubility of carbon in delta iron at high temperatures (in excess of 1400 deg. cent. or 2550 deg. fahr.). It is scarcely to be considered that at such a temperature any phase could long remain supersaturated, and yet in an alloy of 20 per cent chromium, polyhedral grains of delta-iron solid solution have been preserved at room temperature without a trace of carbide precipitation when the alloy contained 0.50 per cent carbon. Upon reheating

[3] Metallurgy of Ferrous Metals, p. 33.

[4] Transactions of the American Society for Steel Treating, vol. 9, no. 1, Jan., 1926.

such grains of delta iron at 750 deg. cent. (1380 deg. fahr.) the excess carbide is precipitated within the grains.

IMPACT TESTS ON NICKEL-CHROMIUM STEELS[5]

The impact resistance of nickel-chromium steel was found to vary according to the type of fracture obtained. Four samples, showing silky fibrous, crystalline, slightly reedy, and very woody fractures, respectively, and with 0.33 to 0.40 per cent carbon, 1.35 to 1.68 per cent nichrome, and 0.55 to 1.60 per cent chromium, were cut into standard Izod-test specimens. The latter were quenched in oil from 325 deg. and tempered at various temperatures between 150 and 540 deg. followed by air cooling, and were tested for impact resistance and Brinell hardness. With tempering below 370 deg. the hardness curves were irregular and all the impact fractures were crystalline. The "silky fibrous" sample showed the best impact resistance, and the "crystalline" and "woody" samples the lowest. The Brinell hardness gives no indication of brittleness. The character of the steel as shown by the fracture was constant, regardless of heat treatment. A short bibliography is given in the original paper.

MACROSCOPIC EXAMINATION OF IRON AND STEEL

It is only comparatively recently that serious attention began to be paid to examination of macrostructure of iron and steel, although the process itself is, of course, older even than microscopic examination. Macroscopic examination lacks the extreme detail shown by microscopic examination, but it has the advantage of showing the aggregate effect of these details, and on a scale which shows their relationship to the form and size of the section of material being examined. Besides furnishing direct information as to certain matters such as presence of non-metallic inclusions, macroscopic examination may be used also to select the spots which should be subjected to the more detailed microscopic examination.

In a paper before the American Society for Steel Treating,[6] F. P. Gilligan and J. J. Curran discussed in particular the macroscopic examination after a hot-acid etch. In this case the specimen is immersed in a strong solution consisting of hydrochloric acid in water alone or with sulphuric acid. (Proportions given in the original article.) Metal that is sound, homogeneous, and relatively free from inclusions or dirt is only slowly and evenly attacked by the acid. Inclusions are, however, quickly dissolved out and the metal itself is attacked more powerfully due to the increased surface thus exposed. As a result metal containing large amounts of dirt evenly distributed will be deeply pitted throughout. The flow of metal in forging and heading operations may be disclosed by means of the hot-acid etch, applied preferably to the longitudinal sections, the changes in direction of "fiber" being usually quite prominent. The etch may also be applied to show effects produced in the steel after treatment and in service, as, for instance, hardening characteristics, grinding characteristics, fatigue characteristics, etc. A certain amount of skill and care must be excerised in this test.

ETCHING REAGENTS

The matter of selection of etching reagents was briefly referred to on page 55 of Metallurgy of Ferrous Metals. Hitherto in literature there appears to have been no well-established rational rule by which etching reagents might be employed for the indentification of certain constituents in plain-carbon and alloy steels, particularly in the latter. The Bureau of Standards[7] has recently undertaken an investigation with the aim of finding a rational rule by which one could be guided in the etching proeedure. The present investigation deals with the identification of such constituents as found in chrome, tungsten, vanadium, and high-speed steels. The conclusion to which the investigation comes is that neither the heat-tinting method nor etching with acidic solution offers satisfactory means of distinguishing between the alloying constituents of the above-enumerated steels. Solutions containing alkali and electrolytic etching present, however, a satisfactory means when properly used. Tungsten carbide can be distinguished from chromium carbide mainly by its characteristic crystalline form and not by its response to etching methods.

ULTRA-VIOLET METALLOGRAPHY

In the field of the application of special methods of microscopy to metallography a truly important advance is described by Francis F. Lucas.[8] In this, advantage is taken of the increase in resolving power which accompanies a decrease in the wave length of light employed, and an instrument has been built by the Zeiss Scientific Staff to order of the Bell Telephone Laboratories in which, by means of quartz parts, a wave length of 275$\mu\mu$ is used. This brings it within the ultra-violet region of the spectrum, and quartz had to be used because ordinary glass absorbs ultra-violet light almost completely. The application and use of ultra-violet metallography requires a very high degree of skill. On the other hand, by means of this monochromatic method a sharpness of detail is produced which seems to be unattainable within the conventional apochromatic system. Ultra-violet light has selective properties which should help to identify structures. For example, it appears that certain constituents of hardened steel absorb ultra-violet light more readily than do other constituents. It is quite likely that this same characteristic will be found in connection with other metals. It is known that many colorless organic subjects show the effects of selective absorption of ultra-violet light, and although they show no signs of color by white light, they respond to ultra-violet light as though colored.

The ultra-violet microscope can be said to have lived up to expectations. Crisp, brilliant images can be obtained which surpass in quality those obtainable with the apochromatic system. The potential resolving ability of the monochromatic system can be realized in practice and the practical application of the ultra-violet microscope should develop much new information. The ultra-violet microscope is the most complicated of any within the realm of technical or scientific microscopy. It requires a highly developed technique for its successful manipulation and the specimens must be prepared with great care. The ultra-violet equipment appears to have a potential resolving ability probably greater than twice that of the apochromatic system.

The difficulty in the present ultra-violet equipment is to obtain real critical illumination. Even very slight decentering produces flares and inequalities of illumination which are wholly ruinous to definition.

X-RAY PHOTOGRAPHY

Some of the practical applications of X-ray photography have been indicated on pages 58 and 59 of Metallurgy of Ferrous Metals. Lately the monochromatic pinhole method has been applied for the practical identification of working and heat-treating processes of metals and for similar purposes.[9] In the monochromatic pinhole method a molybdenum water-cooled-target Coolidge tube operated at 20 milliamperes and 35,000 volts is enclosed in a lead box through the walls of which are inserted heavy brass tubes about 8 cm. long and 3 cm. in diameter, provided with lead plugs fast in each end through which pinholes are made accurately in line by centering in a lathe. The specimen is fixed over the outer pinhole so that the beam grazes it at a definite angle. Apparatus is now available consisting of a steel-lead cylinder in which the tube is placed coaxially so that 18 pinhole and powder diffraction photographs around the cylinder may be taken simultaneously. The value of the monochromatic pinhole method lies in the fact that it discloses that a whole series of specimens with the same fundamental iron lattice may show vastly different properties because they have been worked or heat-treated differently.

By means of this method applied to a hot-rolled piece of low-carbon steel the rolling direction is made clearly evident, as the

[5] J. W. Percy, Michigan Engrg. Experiment Station Bulletin No. 2, 13 pp. (1925). Also in *Chemical Abstracts*, vol. 20, no. 16, Aug. 20, 1926, pp. 2645–2646.

[6] Transactions of the American Society for Steel Treating, vol. 10, no. 1, July, 1926, pp. 9–25 and discussion pp. 25–30.

[7] Metallographic Etching Reagents, No. III for Alloy Steels, Edward C. Groesbeck, Scientific Papers no. 518, December 11, 1925, vol. 20, pp. 572–586; includes selective bibliography.

[8] An Introduction to Ultra-Violet Metallography, The American Institute of Mining and Metallurgical Engineers, pamphlet no. 1576-C.

[9] New X-Ray Studies of the Ultimate Structures of Commercial Metals, John L. Clark, E. W. Brugmann and S. D. Heath. *Industrial and Engineering Chemistry*, vol. 17, no. 11, Nov., 1925, pp. 1142–1146.

rolling has produced an orientation of the grains. An inspection of a similar photograph of a cold-rolled piece shows the radial lines much sharper, indicating the much greater fragmentation and exact orienting force applied. A photograph of ordinary tinplate shows how the tin crystals apparently tend to deposit from the melt in the oriented fashion.

CHROMIZING

In Metallurgy of Ferrous Metals, page 61, reference was made to a method of protecting the surface against certain forms of corrosion and heat action by chromizing. As practiced today the chromizing process consists of heating an article in a mixture of aluminum and chromium powder in an atmosphere of hydrogen. This involves certain difficulties which materially raise the cost of operation, one of the most important factors in this direction being the necessity of using a complicated three- or four-stage process of purifying the hydrogen so as to free it from all traces of oxygen and water vapor. However, Jos. Laissus[10] describes a new method of chromizing. In this the steel to be chromized is placed in an iron tube filled with powdered ferrochromium. This tube is carefully closed and luted with a mixture of fireclay and carborundum powder and placed in a second iron tube filled with cast-iron shavings and luted in the same way as the inside tube. In this way the use of hydrogen with all its concommitant difficulties is eliminated and a comparatively simple process employed. It is desirable that the operation be performed in a reducing atmosphere. Tests made by the author of the process have shown that a considerable amount of chromium is obtained and that it is possible to give a finished article a beautiful surface polish. The same method also made it possible to obtain a chromizing effect by using an electrolytic chromium powder of high purity. The paper by Laissus referred to here gives full data as to the temperatures and durations of operation employed.

A METHOD OF OBSERVING FLAWS IN METAL SURFACES

This is very important and yet not easy to detect because, in rolling, some of the metal may be "smeared over" the surface in a very fine layer and thus hide to a large extent the presence of cracks. An apparatus has been described[11] in the past year which has been primarily developed for observing by a direct-deflection method small changes in the effective resistance and inductance of a coil, but which also may be effectively used for detecting flaws and cracks in the surfaces of metal articles. The principle of action of the apparatus is based on the following. When a coil of wire through which an alternating current is flowing is brought near a piece of metal, currents are induced in the metal which have the effect of producing an apparent increase in the impedance of the primary coil, the change in the impedance being a function of the resistance offered by the metal to the induced secondary currents. The resistance offered to the induced secondary currents depends on the conductivity and thickness of the metal plate, and if the change in effective resistance or inductance of the coil is measured; this change will enable the conductivity of the metal plate to be estimated for a given size and shape of coil.

The apparatus, however, may be used to detect flaws and cracks in a metal plate since the slightest crack in the metal is sufficient to put a very high resistance in the path of the induced secondary current in the material of which the plate is made, causing thereby a change in the balance of the Wheatstone bridge. The apparatus consists of a bridge network, with two inductive arms, which is normally balanced. The bridge is supplied with alternating currents, the indicating instrument being a d.c. galvanometer connected through a synchronously driven commutator. One of the arms of the bridge contains the "exploring" coil, which is placed on the metal surface to be examined, and if the commutator is so adjusted as to indicate the current in phase with the applied voltage, its deflection is proportional to the change in effective resistance of the exploring coil. With the commutator adjusted to observe currents 90 deg. out of phase with the applied voltage, the deflection depends on the change in effective inductance of the coil when this change is brought about by the presence of a metal plate. For non-magnetic materials it is best to use the commutator in the "out of phase" position. The change in effective inductance depends on the specific conductivity of the plate, and the apparatus may be used for quickly comparing the specific conductivities of metal plates. If such plates have cracks normal to the surface, their presence is indicated by a reduction in the galvanometer deflection as the coil passes over a crack.

DILATOMETRIC METHOD OF HEAT TREATMENT

This method is based on a well-known fact that volume of a steel or piece changes on heating or cooling the latter through its critical point (compare Metallurgy of Ferrous Metals, page 75). There are several devices now on the market in this country and Europe making use of this phenomenon. One such device is described by O. E. Harder, R. L. Lowdell, and A. C. Forsyth.[12] In the discussion of this paper R. W. Woodward showed a Rockwell dilatometric outfit attached to an electric pit-type furnace. The equipment as shown is arranged with an indicating dial to show the expansion of the steel progressing throughout the critical transformation range and also an autographic attachment which produces a continuous record of the length changes.

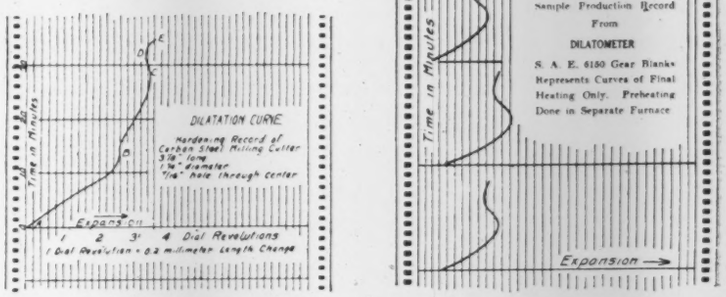


FIG. 1 CHARACTERISTIC DILATATION CURVE ON CARBON STEEL

Fig. 1 shows a record as produced in the hardening of a carbon-steel milling cutter. Point *A* on the chart indicates the dimensional size at the time the work was placed in the previously heated furnace but with the heat supply shut off and the dilatometer brought in contact. The work expands at a decreasing rate to the point *P* corresponding to the amount of residual heat in the furnace. In other words, at the point *B* a temperature equilibrium between work and furnace exists, and all parts of the work are equally expanded. At *B* the fuel supply to the furnace is again applied so as to bring up the temperature of the work and the furnace at the same rate. Expansion of the work is again resumed and decreases slightly before the point *C*, at which point there is a reversal in the direction of the curve. This reversal marks a contraction in the work, and is an exact indication that the steel is entering the critical transformation range. This contraction continues until the transformation is completed at *D* on the curve. At the completion point *D* reëxpansion then takes place, at which time the work is removed from the furnace for quenching. As a convenience to the operator an alarm attachment is provided so that a bell rings when point *C* is reached and continues to ring until point *D* is reached. It is also possible through suitable relays to arrange so that an additional signal is given when the point *D* is reached and the hardener is forcibly reminded that it is time to quench the article.

A_2 LINE IN THE IRON-CARBON-SYSTEM EQUILIBRIUM DIAGRAM

It has been pointed out in Metallurgy of Ferrous Metals (page 76) that the Japanese metallurgist, Kotaro Honda, claims that the A_2 point is not a change of phase but is due to the increase of the rotational energy about the magnetic axis of the iron atoms.

[10] *Revue de Metallurgie*, vol. 23, no. 3, Mar., 1926, pp. 155–178.

[11] Prof. E. W. Marchant and J. L. Miller in The Journal of the Institution of Electrical Engineers, London, vol. 64, no. 355, July, 1926, pp. 737–744.

[12] Transactions of the American Society for Steel Treating, vol. 9, no. 3, March, 1926, pp. 403–412 and discussion 412–419.

In a more recent publication[13] the same metallurgist says that the A_2 transformation in iron and steel is a continuous change extending from the lowest temperature up to the A_2 point and is not in any way a change of phase. The A_2 point as given in the diagram does not represent temperature at which transformation takes place but only the initial temperature during cooling or the final temperature during heating. He also asks the question, "What are alpha and gamma irons?" and gives the following as the most appropriate answer:

> The iron which has a body-centered cubic lattice is called the alpha iron, and that which has a face-centered cubic lattice, the gamma iron. The usual expressions, such as "alpha iron is magnetic" or "gamma iron is non-magnetic" do not fit the actually observed facts. For delta iron which is formed at a temperature above 1400 deg. is now known to be the same as alpha iron, but it is not magnetic. Austenitic iron or steel is generally non-magnetic (or paramagnetic), but not always so; for steels containing carbon in the vicinity of the eutectoid concentration are, as is shown above, slightly magnetic for some thirty degrees and nickel-iron alloys containing more than 30 per cent of nickel have also an austenitic structure—that is, their atoms assume a gamma configuration, but they are all strongly magnetic at room temperature. In fact, magnetism is an atomic property and may therefore vary independently of the alpha or gamma configuration of the iron atoms.

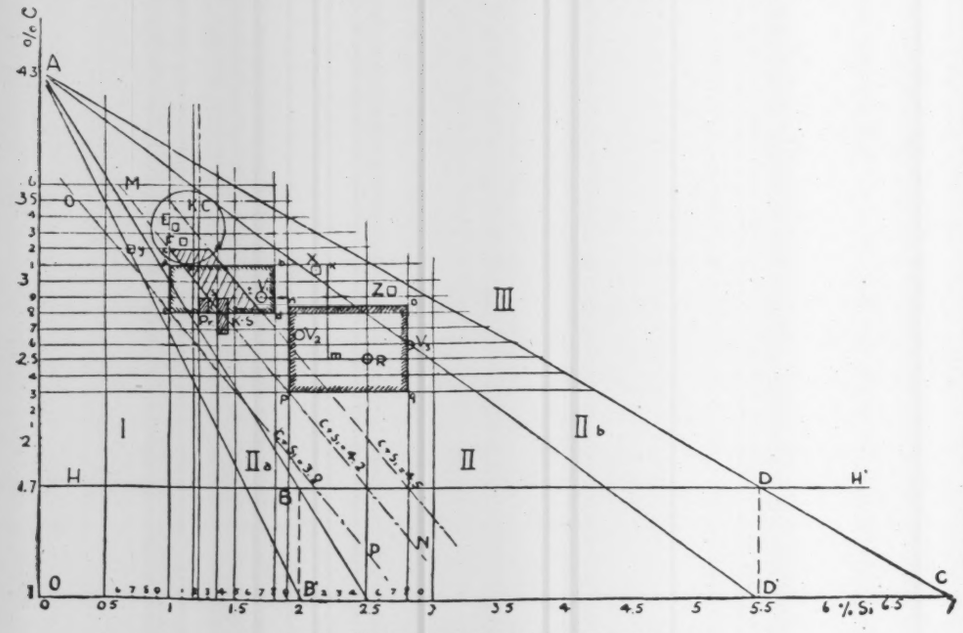


Fig. 2 Maurer's Cast-Iron Diagram

(I, White iron; II, pearlitic cast iron; III, ferritic cast iron; II, IIb, III, gray cast irons; IIa, mottled iron; *K-C* (circle), Krupp cylinder iron; *F*, Bauer-Lanz pearlitic cast iron; *E*, Emmels' pearlitic cast iron (1924); *abcd*, Le-Thomas' pearlitic cast iron; *X*, semi-steel (Cameron); *crst*, Prache steel-cast irons; *Pr*, idem; *iklm*, Wüst & Bardenheuer's pearlitic cast iron; *nopq*, Thyssen-Emmel pearlitic cast iron; *R*, C = Si = 2.5 maximum strength, Thyssen-Emmel; *CD-MN*, limits of pearlitic cast iron, Lanz process (according to Buffet); *Y*, Lanz (Buffet) pearlitic cast iron; V_1, V_2, V_3, pearlitic cast iron (Varlet's experiments); *Z*, cast iron with pearlite and ferrite, Walter process.)

Carburization

A series of tests, the purpose of which is to establish the mechanism through which the carbon is conveyed from the surface into the steel, is discussed in a paper by W. E. Day, Jr.[14] The general formula of diffusion is somewhat similar to that expressing the flow of heat, but holds true only when the distance through which diffusion occurs is infinitely small. The expression given contains a constant of diffusivity which varies with temperature and must be found by experiment, and experiments leading to the determination of the value of this constant of diffusivity in a nickel steel are described. It is found that although the rate of diffusion is dependent both upon the value of the constant of diffusivity and upon the difference in concentration, the greatest effect is due to the change in the value of constant of diffusivity with changes of temperature. However, the true relation of time and temperature to depth in the nature of the rays has not yet been expressed by any simple relation.

[13] Journal of the Iron and Steel Institute, vol. 112, 1925, no. II, pp. 345–348.

[14] Transactions of the American Society for Steel Treating, vol. 9, no. 2, Feb., 1926, pp. 240–258 and discussion pp. 257–258.

The Maurer Carbon-Silicon Diagram of Cast Irons

On page 96 of Metallurgy of Ferrous Metals there appeared a diagram developed by Dr. Eduard Maurer in which cast irons were classified by their carbon-silicon contents. As developed by Maurer the diagram was comparatively simple. Louis Piedboeuf's[15] diagram, however, shown in Fig. 2, is a far more developed form.

Maurer included in his diagram cylinder cast irons and Krupp special cast irons, and also the results of laboratory tests carried out by Wüst and Bardenheuer. Fig. 2 has been supplemented by points showing a whole collection of special irons, pearlitic irons, and semi-steels.

Point *F* corresponds to information given by Bauer in 1923 to characterize pearlitic cast irons obtained by the Lanz process. Few data have been published on this method. In a paper published in *La Fonderie Moderne*, Aug., 1925, M. Buffet, engineer of the Société Alsacienne, gives as the distinguishing feature of the Lanz pearlitic cast irons: C + Si = 3.8 to 4.2 per cent. The corresponding zone in the diagram is that included between the two parallel lines *OP* and *Mn*. Part of it comes within the space occupied by the mottled irons, i.e., those with an excess of cementite. This is quite as it should be, because, in the Lanz process, the pearlitic structure is obtained by heating the mold.

The circle *KC* circumscribes Krupp steam-engine-cylinder irons, and the zone *KS* the special high-tensile irons of the same firm.

Point *E* is derived from data published in 1924 by Emmel for pearlitic cast irons as produced by the Thyssen Company. These cast irons are distinguished by Si = Mn = 1.

The zone *crst* included between the lines C + Si = 4.2 and C + Si = 4.5, and the zone marked *Pr* differentiate two types of semi-steel cast iron as suggested by Lt-Col. Prache.

Point *X* indicates the composition of a special semi-steel cast iron used for aerial bombs, and suggested by Cameron.

The zone included within the rectangle *abcd* is that of the pearlitic irons as produced at the Indret works, and as given in a very interesting paper published by M. LeThomas. The rectangle *iklm* is derived from the laboratory researches of Wüst and Bardenheuer.

The zone *nopq* is the region of cast irons produced by the Thyssen-Emmel process. These cast irons are said to give the best results from the point of view of evenness of texture and strength.

The points V_1, V_2, and V_3 indicate the results of a test made by M. Varlet (vice-president of the Belgian Association) at the foundries of the Société Esperance-Longdoz.

It may be presumed that the researches carried out by the Société Alsacienne tend in the same direction, since, in his paper quoted above, M. Buffet mentions the production of cast iron containing 2.3 and 2.5 per cent carbon.

Maurer's diagram clearly points out the advantage of low-carbon contents. The lower the carbon content, the wider the zone of pearlitic structure. There is thus greater certainty of getting the pearlitic structure without the risk of encroaching on adjacent zones. By keeping at an equal distance from the cementite and ferrite zones, there is a greater chance of getting the pearlitic structure without heating the mold.

The same article gives a table showing the mechanical properties of various special irons (Bauer, Lanz, Krupp, Thyssen-Emmel, Kerpely, LeThomas, and Varlet).

[15] Belgian Exchange Paper at the London Convention of the Institute of British Foundrymen, June 19, 1926, published in *The Metal Industry and The Iron Foundry*, vol. 28, no. 26, June 25, 1926, pp. 613–614 and vol. 29, no. 1, July 2, 1926, pp. 17–18.

EMBRITTLEMENT IN MALLEABLE CASTINGS[16]

Malleable-iron castings become frequently brittle as a result of hot-dip galvanizing. An extensive investigation carried out by the metallurgical department of the Ohio Brass Company has shown that the galvanizing itself has nothing to do with the creation of this brittleness, and that it is the heating to a temperature of about 860 deg. fahr. (460 deg. cent.) and the rapid cooling rate that are the important factors. Further research has shown that there is a well-defined range of temperatures (570–1120 deg. fahr. or 300 to 500 deg. cent.), quenching from which produces brittle metal. On the other hand, it has been found that the impact values obtained on quenching from the zone 1100 to 1380 deg. fahr. (600 to 750 deg. cent.) are unusually high—higher than in untreated malleable iron. A method has therefore been developed in which the iron is heated to about 1200 deg. fahr. (650 deg. cent.) and quickly cooled, preferably by quenching in water. It has even been found that this treatment permits reclaiming any iron previously embrittled by galvanizing.

MALLEABLE CAST IRON

An extensive investigation of the mechanism of graphitization or passage from white iron into malleable, together with such subjects as the growth of malleable cast iron, has been carried out by Tario Kikuta.[17] In this investigation, by using a dilatometer, measurements were made of the amount of graphitization which took place when keeping the test specimen at a constant high temperature, as is done in practice when annealing white cast iron, and the progressive degree of this reaction was checked microscopically afterward.

Some of the conclusions at which the author arrives are as follows:

In order to graphitize white cast iron completely, it is essential that after the completion of the graphitization of the free cementite at a high temperature above the A_1 point, the article should be heated just below the A_{-1} point for a prolonged time or cooled very slowly from the A_{-1} range to decompose the eutectoid cementite.

There is an intimate relation between the thickness of the casting and the size of the free cementite, i.e., the size of the free cementite grows as its thickness increases; and the graphitization of the free cementite will become more difficult as its size becomes larger or the casting thicker.

The tapping temperature of the melt also affects the graphitization of white cast iron, and the graphitization becomes more difficult as the temperature is raised.

Silicon has a powerful effect on the graphitization of the first and second stages, and as this content is increased, the time required to complete the graphitization logarithmically decreases.

For the second stages of graphitization, carbon is more effective than silicon, although it hardly affects that of the first stage.

From the results of the present investigation, some rapid heat treatment of a practical sample has been tried and it was possible to obtain black-heart malleable cast iron by heating white cast iron containing more than 2.5 per cent of carbon and 1 per cent of silicon for 54 hr.

From the various phenomena studied in the present investigation, the following conclusion regarding the mechanism of the graphitization of white cast iron is drawn: By means of the catalytic action of free carbon oxides present in the casting, a nucleus of the graphitizing temper carbon is formed principally along the boundary of the cementite, and the graphitization which is to take place successively is accelerated by the affinity between the iron and the included elements.

ELECTRIC SILICON STEEL

This steel is of very great value as a core material for electrical apparatus, particularly in transformers. Laboratory samples have been produced by Yensen[18] with amazingly high permeabilities never approached in commercial sheets. The main facts as to the behavior and composition of electric silicon steel are set forth in W. E. Ruder's paper before the American Iron and Steel Institute, Oct. 23, 1925. From this it would appear that three grades of such steel are used, varying chiefly in the silicon composition. Hysteresis losses are also increased by the presence of mechanical strains so that a thorough anneal must be given to remove all of the strains imparted by rolling. The increase in hysteresis due to punching or cutting into the required pattern for manufacturing purposes is approximately a linear function of the gage.

A very thin scale is of value as an insulator between the sheets, but if too heavy it cuts down the cross-section of active material in the core and reduces the efficiency. Loose scale is a menace as it may get into the windings of the apparatus and cause a short-circuit.

STAINLESS IRON AND STEEL

Stainless iron and steel[19] continue to attract serious attention because of their mechanical properties, and particularly their resistance to certain forms of corrosion. M. L. Mochel[20] has investigated a group of chromium-iron alloys having a carbon content of not over 0.12 per cent (stainless iron) and a chromium content of approximately 10 to 19 per cent.

An extensive program having to do with the effect of elevated temperatures of stainless iron and some other materials is now in progress at the Westinghouse Research Laboratory, sponsored by the South Philadelphia Works. Both "short-time" and "long-time" tests of stainless iron in the annealed and in the quenched and drawn states are being made. Results of "long-time" tests completed to date indicate that annealed stainless iron is susceptible to considerable strain hardening, and this is relieved but very slowly, if at all, at temperatures of 750 deg. fahr.; further, that specimens held under loads up to the proportional limit and at temperatures up to 750 deg. fahr., show no additional deterioration with the time element. This work will be the subject of a joint report at a later date.

Tests to judge the resistance to corrosion have been made on practically all of the materials referred to. Cylinders, disks, and portions of forgings have been subjected to the action of steam, heat, running tap water, salt water, salt spray, stagnant water, atmosphere, and the elements, dilute and concentrated acids, magnesium chloride, calcium chloride and some other conditions. Such tests, in the absence of definite standards, can only serve to indicate the general behavior, and for the present purpose, general results or conclusions will be given rather than many meaningless figures. The general indications are:

1 That heat treatment which is so essential to bring out the resistance to corrosion in the higher-carbon stainless steel, appears entirely unnecessary with stainless iron.

2 That alloys of increasing chromium content, and especially those of high chromium content containing silicon, appear to offer more marked resistance than the low-chromium alloys.

3 That increased silicon gives greater resistance to scaling.

4 That the addition of 1 per cent copper appears to increase the resistance of salt water or spray.

5 That a properly prepared pickled surface is quite resistant to actual corrosion, although it may show some superficial rust. A case in mind is that of a forging with an improperly prepared pickled surface being left on an outdoor scrap pile for several weeks. A coating of rust appeared all over. Leaving one third of the surface in this rusted state, a second third was properly pickled, and the other third polished. After being outdoors subject to the elements for nearly two years, the rusting of the original third has progressed no further and the other portions are without change.

Of especial interest to many is the resistance of these materials to the corrosive and erosive action of wet and dry steam under varying conditions up to 750 deg. fahr., with and without foreign or other matter which would accelerate either action. Fig. 3 shows a small machine for the purpose of making a study of this matter, which study is now in progress. It consists of a steam-tight casing in which a shaft is revolved by means of a pulley, driven

[16] L. H. Marshall in *The Iron Age*, vol. 117, no. 8, Feb. 25, 1926, pp. 558–560.

[17] On the Malleable Cast Iron and the Mechanism of Its Graphitization, *Science Abstracts* of Tohoku Imperial University, 1 Series, vol. 15, no. 2, May, 1926, pp. 115 to 155, and numerous tables and plates.

[18] Journal of the Institute of Electrical Engineers, vol. 43, 1924, pp. 558 and following, and references cited therein.

[19] Principles of Metallurgy, pp. 61 and 127.

[20] Transactions of the American Society for Steel Treating, vol. 10, no. 3, Sept., 1926, pp. 353–392, including bibliography and discussion pp. 392–394.

by a motor not shown. The shaft at its opposite end carries a disk and deflector, with ten specimens secured to the disk as shown. Steam or water entering by means of the nozzle is deflected against the sharp edges of the specimens. A second nozzle, not shown, permits of the steam or water impinging directly on the specimens without the use of the deflector. Both nozzles are provided with an injector arrangement permitting the introduction of any chemical or gas into the steam or water. The purpose of revolving the specimens is to secure uniform subjection of all specimens to the corroding or eroding medium, something which is often unaccomplished in many corrosion tests. Stainless iron is being examined extensively in this way, and the results will be available at a later date.

The hot working of stainless steel requires more than ordinary care, but the alloys in general may be cold-rolled, drawn, upset,

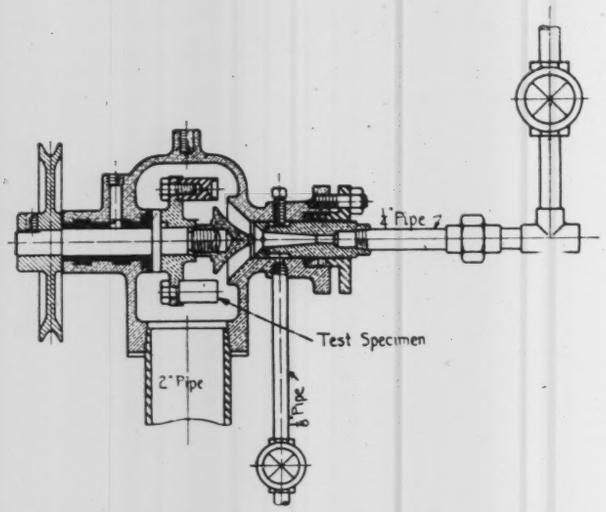


FIG. 3 SKETCH OF CORROSION AND EROSION TEST APPARATUS

pressed, and otherwise cold-worked. Experience has shown that the amount of work between anneals and the speed of working are greatly reduced over soft carbon steel, and the wear on rolls, dies, or other tools greatly increased. Where expedient, cold rolling is practiced in preference to cold drawing. For annealing, dead-softness will result by heating to 1800 deg. fahr. and cooling very slowly; but for most cold-working operations, annealing at 1400–1500 deg. fahr. and cooling in the furnace or air will be sufficient.

PROBABILITY CURVES IN METALLURGY

In every branch of engineering the interpretation of engineering data is at times as perplexing a problem as their collection. This applies particularly to the field of selection of engineering materials where a large number of variables have to be taken into consideration. The method of representing results of phenomena under changing conditions by means of a straight-line curve which affords sufficient information when applied to simpler phenomena, fails completely in such a highly variant science as applied metallurgy. B. D. Saklatwalla and H. T. Chandler[21] have therefore worked out a method of applying probability curves to metallurgy. They use a bell-shaped curve and have shown that when based on a sufficient number of observations, it gives useful indications of a practical character. This method has been applied to the predetermination of the Brinell hardness of flywheels by the use of certain practical mixtures and practices in their manufacture.

DETECTION OF SEAMS IN STAMPING OF METAL[22]

In the stamping of metals the location of the seam plays an important part in the flowing of the metal between the two matrices. This flowing of turn determines the structure of the product and therefore its physical properties. The proper design of matrix and seam is determined by a study of the macrostructure of various cross-sections of the piece, in connection with which chemical attack of a polished section is of extreme value in revealing the orientation of the grain structure of the metal. A solution containing 40 cc. of concentrated HCl, 30 cc. of water, 25 cc. of 95 per cent EtOH and 5 g. of $CuCl_2$ gives excellent results as an etching reagent, even with steels containing 13 to 14 per cent chromium and 0.45 per cent carbon and with tungsten steels. Its action is so rapid that 10 min. suffices for obtaining the necessary corrosion, and the solution can be used repeatedly.

TEMPER BRITTLENESS

A physical investigation into the cause of temper brittleness was made by Prof. J. H. Andrew and H. A. Dickie.[23] Their experiments proved that in steels susceptible to temper brittleness a moderate rate of cooling (2 deg. or 3 deg. cent.) per minute produces a considerable fall in specific volume and in hardness. The moderate rates of cooling which produce this physical change are known to produce comparatively small variations in impact value. The magnitude of this physical change appears therefore to be proportional to the degree of brittleness which may be produced by very slow cooling. In explanation of this, it is suggested that a certain amount of carbide is present in solid solution in alpha iron (which may be nickel or chromium ferrite) at tempering temperatures, and that this carbide is partially, at least, deposited in a fine state of division throughout the mass of moderately slow cooling.

It would appear that there is a tendency for certain special elements, such as nickel, manganese, chromium, and phosphorus, to increase the solubility of carbide in ferrite at temperatures near to the Ac_1 range and to redeposit it from solution at lower temperatures on slow cooling. On the other hand, the addition of a small quantity of molybdenum is believed by the authors to eliminate brittleness by effecting the retention of carbide in solid solution in alpha iron no matter what be the rate of cooling. The deposition of carbide from solid solution will not, however, in itself produce any great degree of brittleness in a steel and it is evident from the present work that another physical change is induced in the steels by very slow rates of cooling. It has been clearly proved that very slow rates of cooling give a considerable increase in the specific volume and in the hardness when compared with the va'ues obtained by moderate cooling rates.

FATIGUE FAILURE OF METALS

H. F. Moore[24] attempts to explain the fatigue failure of metals starting from the theory of slip lines.[25] He also brings to bear upon the problem the work of A. A. Griffith and the Russian physicist Joffe.

The elastic limit of yield point cannot be determined readily from microphotographs, and the determination is usually made from the data of an actual mechanical test of the material. The most accurate determination of these limits is made from a diagram drawn with stress as ordinates and strains as abscissas—the ordinary stress-strain diagram. The endurance limit or fatigue limit is most readily determined by actual tests of specimens to destruction under repeated stress.

In considering the fatigue of metals under repeated stress, it becomes necessary to recognize that the ordinary formulas for stress and strain are strictly true only for an ideal metal, homogeneous and without any discontinuities (flaws) in it.

Actual metals are not ideal in this respect and hence for them the ordinary formulas for stress and strain have a high degree of precision only if a large number of crystalline grains are considered together.

Actual metals do not develop strengths under load so great as would be expected from the computed "cohesion" of their atoms. Under repeated stress their strength is still smaller, and under reversals of stress the strength of metals is even lower than under repetitions of stress not involving reversal.

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[21] Application of the Mathematics of Probability to Experimental Data as a Basis for Appropriating Choice of Ferrous Materials, Transactions of the American Society for Steel Treating, vol. 10, no. 2, Aug., 1926, pp. 195–205 and discussion pp. 205–213.

[22] E. Decherf, *Revue Universelle des Mines*, vol. 7, no. 10, 1926, pp. 162–168. Also in *Chemical Abstracts*, vol. 20, no. 16, Aug. 20, 1926, p. 2650.

[23] Paper presented before the Iron and Steel Institute, Stockholm Meeting, Aug. 17–28, 1925, and published in *Engineering*, vol. 122, nos. 3172–3173, Oct. and Nov. 6, 1926.

[24] *Journal of the Franklin Institute*, vol. 202, no. 5, 1925, pp 647–658.

[25] Metallurgy of Ferrous Metals, p. 42.

1926 A.S.M.E. Student Prize Award Paper

An Investigation of Stress Concentration by Means of Plaster-of-Paris Specimens

By R. E. PETERSON,[1] WILKINSBURG, PA.

In this paper the author shows that the determination of stress-concentration factors by means of plaster-of-paris specimens is a simple means of obtaining results which are close to or on the safe side of fatigue results. Mathematical stress-concentration factors based on the theory of elasticity, as well as photoelastic factors, differ considerably from fatigue results for small holes and small fillets.

Tests to determine stress concentration in loaded members due to holes, fillets, grooves, and threads are described.

Three-dimensional problems in stress distribution, which cannot be solved photoelastically, may be investigated by tests of plaster-of-paris specimens, which are not difficult to make and may be machined very nicely.

STRESS CONCENTRATION occurs in a loaded member wherever there is a sudden change of cross-section, such as at fillets, keyways, holes, or threads. The resulting increased stress cannot be computed by simple formulas of mechanics and in only a few cases can it be computed by elaborate analyses based on the theory of elasticity.

In practical application, the widest field for the use of stress-concentration data is probably in connection with members subject to fatigue. Motor-generator shafts, car axles, turbine shafts, high-speed machine-tool spindles, crankshafts and reciprocating parts of internal-combustion engines are subject to a complete cycle of stress every time a rotation takes place. Many failures have occurred in such places because the significance of stress concentration in connection with fatigue has not been realized.

Because of the importance of stress concentration, various methods of attack have been developed, some of which are most elaborate.

The method used in this investigation is the brittle-material method,[2] similar in principle to that used by Bach in his torsion tests of cast iron. It is necessary that the specimens be made of a material which has a practically straight-line stress-strain diagram up to failure. Plaster of paris was found to be a very suitable material from this standpoint, and was therefore used for this investigation.

The brittle-material method is very simple in principle. Assume two tension specimens, one containing a hole and the other having the same net cross-sectional area, but with no hole (Fig. 1a).

These two specimens are then tested to failure and the breaking load P_1 for the specimen without a hole and P_2 for the specimen with a hole are obtained. The ultimate strength of the material may then be computed, $S_1 = P_1/a$, based on the specimen without the hole. S_1 is assumed to be equal to S_h, the localized stress at the edge of the hole at failure, since both S_1 and S_h represent the ultimate unit stress at which the particles of the plaster tear apart.

$$S_1 = \frac{P_1}{a} = S_h$$

The actual stress distribution due to a hole is as shown in Fig. 1a. The stress which would exist at the load P_2 if the specimen were of the same net area and did not contain a hole, is $S_2 = P_2/a$. Then

$$\frac{S_h}{S_2} = \frac{P_1}{P_2}$$

The "stress-concentration factor" for a member containing an irregularity is the ratio of the actual maximum unit stress caused by the irregularity to the maximum unit stress as computed by an ordinary formula of mechanics, using the net area and assuming no irregularity.

Fig. 1 shows examples of stress concentrations. In each case the stress-concentration factor $F = S_h/S_2$.

According to the above definition, the stress-concentration factor F is the ratio of the stress S_h at the edge of the hole to the stress S_2 which would exist in a member having the same net cross-sectional area and not containing a hole.

$$F = \frac{P_1}{P_2}$$

In obtaining stress-concentration factors, therefore, it is not necessary to compute stresses at all, but simply to compare the breaking loads.

Stress concentration due to holes was investigated first. Simple beam tests were found to be most satisfactory and easy to perform. The holes were drilled vertically through the center of the beam, as shown in Fig. 2, thus placing the hole on one surface in compression and that on the opposite surface in tension.

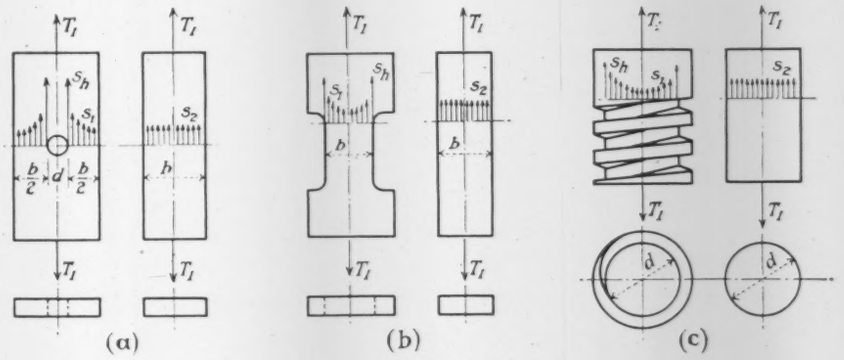

FIG. 1 EXAMPLES OF STRESS CONCENTRATION

A Scott vertical testing machine of 250-lb. capacity was used, and the load at failure was automatically indicated on a scale. The specimens were first broken on a 12-in. span, and later the resulting halves were broken on a 6-in. span. The effect of the various-sized holes was investigated.

As has been explained, it was unnecessary to compute stresses in order to obtain stress-concentration factors. In this case, however, the stress-concentration factors could not be obtained as the ratio of the breaking loads alone, because any two comparison beams did not have the same net cross-sectional area, due to the hole in one of them. By a method similar to that explained, the stress-concentration factor for a rectangular beam specimen may be shown to be

$$F = \frac{P_1 b_2}{P_2 b_1}$$

where P_1 = breaking load of specimen without hole
P_2 = breaking load of specimen with hole
b_1 = width of specimen without hole
b_2 = net width of specimen with hole.

Using this formula and the average breaking loads given in Table 1, the stress-concentration factors have been computed and are also given in Table 1. These results are shown graphically in Fig. 3.

[1] Graduating thesis submitted in June, 1926, to the faculty of the University of Illinois, Urbana, Ill. The work was done in the Materials Testing Laboratory under Prof. H. F. Moore. Abridged.

[2] Bach, C. Elastizität und Festigkeit. Eighth edition, pp. 342–401.

It is interesting to compare the data obtained with analytical results. The following formula for the stress at the transverse section of a plate of infinite width having a hole and subjected to uniform tension is due to Föppl.[3]

$$S_t = \frac{S}{2}\left(2 + \frac{a^2}{r^2} + \frac{3a^4}{r^4}\right) \quad \ldots\ldots [1]$$

where S = applied stress (see Fig. 5) in lb. per sq. in.
a = radius of hole in inches
r = distance in inches from center of hole to point at which value of stress is desired.

The stress distribution according to this equation is shown graphically in Fig. 4. At the edge of the hole, $S_t = 3S$, as may be seen by making $r = a$ in Equation [1].

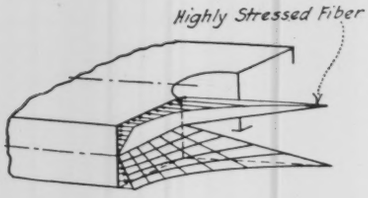

FIG. 2 STRESS DISTRIBUTION IN A BEAM CONTAINING A VERTICAL HOLE

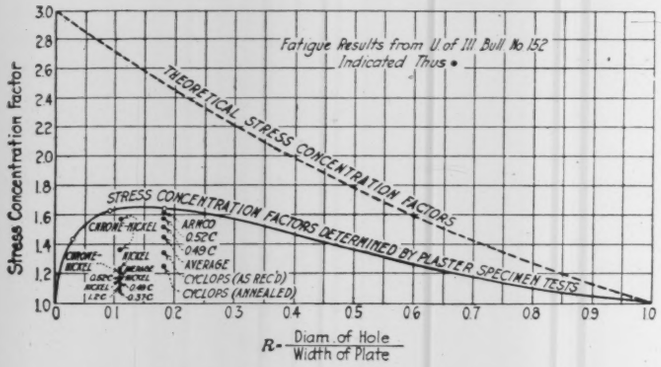

FIG. 3 STRESS-CONCENTRATION FACTORS DUE TO HOLES

Inasmuch as the above theory is based on a plate of infinite width, corrections must be made for beams of the width used in the tests. The following formula[4] was derived from equilibrium conditions by assuming that the same form of stress distribution exists for finite widths.

$$F = \frac{6\,(n-1)}{2n - \frac{1}{n} - \frac{1}{n^3}} \quad \ldots\ldots [2]$$

where F = stress-concentration factor and
n = ratio of $\dfrac{\text{width of plate}}{\text{diameter of hole}}$

A curve of theoretical stress-concentration factors representing Equation [2] is shown in Fig. 3.

Fatigue results obtained by Moore and Jasper[5] are also shown in Fig. 3. It will be noticed (Fig. 3) that the curve of stress-concentration factors obtained by testing plaster specimens approaches unity for small holes. This tendency has been noticed in other types of investigation also.

It may be concluded, therefore, that the mathematical analysis based on the theory of elasticity does not give stresses that are indicative of the strengths of members containing small holes and made of such materials as are used in engineering structures.

[3] Föppl, A., Vorlesungen über Technische Mechanik, vol. 5, p. 352. The mathematical determination of the stress concentration due to an elliptical hole was first made by Kolosoff in 1909, but his work is published only in his thesis at St. Petersburg.

[4] Derivation in Peterson's thesis, Part III, Section E (at University of Illinois library).

[5] Moore, H. F., and Jasper, T. M., An Investigation of the Fatigue of Metals, University of Illinois Experiment Station, Bulletin No. 152, p. 25.

TABLE 1 DATA ON PLASTER SPECIMENS WITH HOLES

Diam. of hole, in.	Average breaking load, lb.	Stress-concentration factor
0	66.5	....
1/16	45	1.43
3/16	37	1.63
3/8	33	1.64

TABLE 2 FILLET TEST DATA

(Round Plaster Specimens)

Specimen	ρ/d	Breaking load, lb.	Stress concentration factor	Average stress-concentration factor
A_1	St.*	107		
A_2	1/3	83	1.289	
B_1	St.	81		
B_2	1/3	66	1.227	1.258 for ρ/d = 1/3
C_1	St.	96		
C_2	1/12	72	1.333	
E_1	St.	119		
E_2	1/12	88	1.353	
F_1	St.	106		
F_2	1/12	74	1.432	1.373 for ρ/d = 1/12
G_1	St.	128		
G_2	1/48	81	1.580	
H_1	St.	101		
H_2	1/48	60	1.684	1.632 for ρ/d = 1/48
J_1	St.	72		
J_2	Sharp corner	37	1.946	
K_1	St.	111		
K_2	Sharp corner	59	1.881	
L_1	St.	68		
L_2	Sharp corner	37	1.838	1.888 for ρ/d = 0 (sharply machined corner)

NOTE: D/d = 2, all specimens, ρ = radius of fillet; D = largest diameter, d = smallest diameter of specimen.
* St. = Standard specimen of large radius.

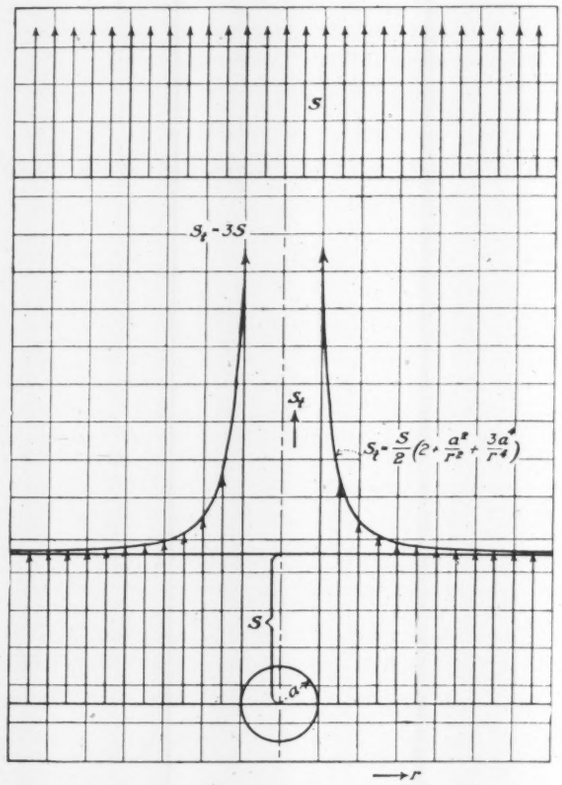

FIG. 4 THEORETICAL STRESS DISTRIBUTION IN A PLATE HAVING A HOLE

Photoelastic results agree very well with the mathematical analysis for small holes, and therefore the above considerations apply to photoelastic results also.

It will be noticed that all of the fatigue results are below the plaster-of-paris curve. Therefore, the plaster-of-paris stress-concentration factors are quite probably on the side of safety if used for determining the fatigue strengths of steel parts in which there are holes.

The next problem investigated was the stress concentration due to fillets. The plaster was cast in cylindrical molds and the specimens turned in the ordinary type of engine lathe. The center portions (Fig. 5) were cut by means of special forming tools. The standard forming tool produced a specimen having no appre-

ciable fillet effect, but which would break as a cylinder of diameter equal to the smallest diameter of the actual specimen.

The specimens were tested as beams, the Scott apparatus previously referred to being used. The two equal loads, giving a uniform bending moment between them, eliminated the effect produced by a concentrated load at a critical section. All specimens were made with the largest diameter twice as great as the smallest, or $D/d = 2$.

Specimens having the following sizes of fillets were tested: $^1/_2$ in., $^1/_8$ in., $^1/_{32}$ in., and a sharply machined corner. As the smallest diameter was always $1^1/_2$ in., the corresponding values of $\rho/d = \frac{\text{radius of fillet}}{\text{smallest diameter}}$ were $^1/_3$, $^1/_{12}$, $^1/_{48}$, and 0 (approx.)

It has been shown that where the cross-sections of comparison specimens are the same, the stress-concentration factors may be obtained by comparing the breaking loads. As the cross-sections of the fillet specimens were always made the same, it was only necessary to compare breaking loads to obtain fillet stress-concentration factors.

The breaking loads of the fillet specimens are given in Table 2 and the resulting stress-concentration factors are shown graphically in Fig. 6.

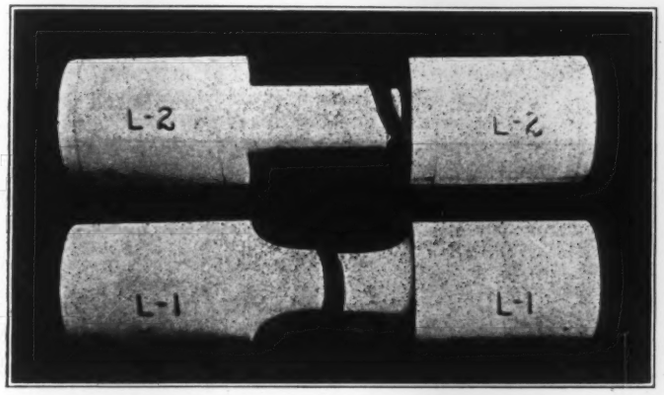

FIG. 5 PLASTER-OF-PARIS FILLET SPECIMENS

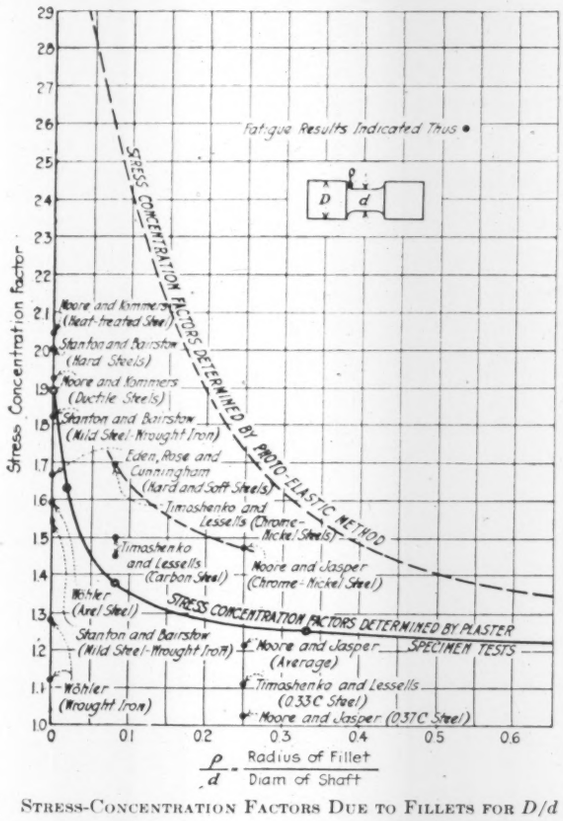

FIG. 6 STRESS-CONCENTRATION FACTORS DUE TO FILLETS FOR $D/d = 2.0$

Photoelastic results obtained by Timoshenko and Dietz[6] have been given in the form of a curve in Fig. 6. Fatigue results obtained by Wöhler,[7] Stanton and Bairstow,[8] Eden, Rose and Cunningham,[9] Moore and Kommers,[10] Moore and Jasper,[11] and Timoshenko and Lessells[12] are shown for comparison.

As was the case with holes, the photoelastic stress-concentration factors are much higher than either the plaster-of-paris factors or the fatigue factors for small fillets.

The curve representing results obtained with plaster-of-paris specimens having fillets is not always on the safe side when compared with fatigue results, as was found to be the case for specimens with holes. Chrome-nickel steel has relatively high stress-concentration factors. For ordinary steels, the curve representing results obtained with plaster-of-paris specimens having fillets also represents fatigue results fairly well.

One other problem was investigated, that of the stress concentration due to threads. In an ordinary threaded test specimen, failure generally occurs at the end of the threads and thus true

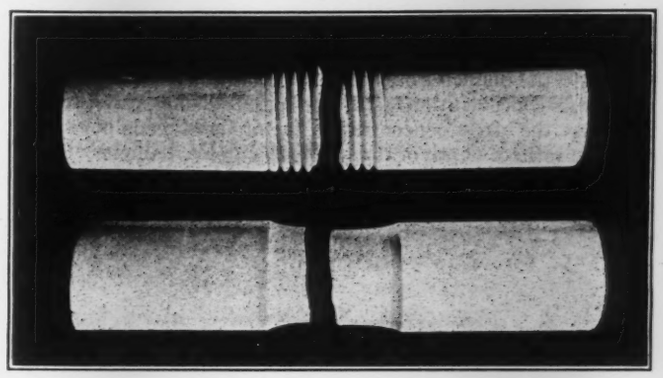

FIG. 7 THREAD TEST SPECIMENS
(Top—U.S.S. threads, 4 per in.; bottom—standard specimen.)

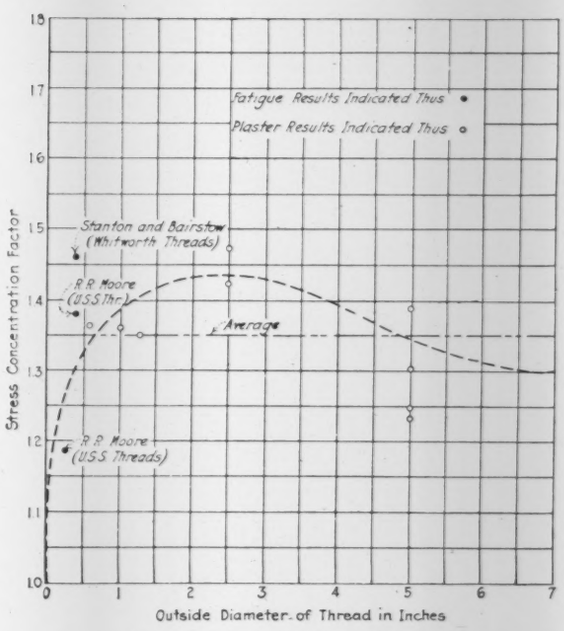

FIG. 8 STRESS-CONCENTRATION FACTORS DUE TO U.S.S. THREADS

[6] Timoshenko and Dietz, A.S.M.E. paper presented at Spring Meeting at Milwaukee, Wis., May 18 to 21, 1925.

[7] Wöhler, *Engineering* (London), vol. 40, 1871.

[8] Stanton and Bairstow, Inst. of Mech. Engrs. (British), 1905–6, vol. 166, IV, p. 78.

[9] Eden, Rose and Cunningham, Inst. of Mech. Engrs. (British), 1911, (III, IV), p. 839.

[10] Moore and Kommers, University of Ill. Exp. Sta., Bulletin No. 124, p. 105.

[11] Moore and Jasper, University of Ill. Exp. Sta., Bulletin No. 152, p. 25.

[12] Timoshenko and Lessells, Applied Elasticity (Westinghouse Technical Night School Press, East Pittsburgh, Pa.), p. 481.

results for the threads themselves were not obtained. In order to overcome this difficulty a special device was made for a lathe which caused the roots of the threads to follow a surface similar to that of the standard fillet specimen (see Fig. 7). Consequently, full-depth threads occurred only at the middle.

The standard forming tool used for the work with fillets was also used for turning standard specimens not having threads (Fig. 7). The smallest diameter of the standard specimen was always made equal to the root diameter of the corresponding specimen having threads.

U.S.S. (Sellers) threads were investigated, as most threads in practice in this country are of that kind. The ratio of the depth of thread to the diameter of shaft is not constant, so it is necessary to find stress-concentration factors for various diameters. It was assumed that the stress-concentration factor for threads is constant for a given ratio of depth of thread (d) to outside diameter (D).

The relation between the depth of thread and the number of threads per inch for U.S.S. threads is:

$$d = \frac{0.6495}{n}$$

Therefore, if for two specimens, $\frac{d_1}{D_1} = \frac{d_2}{D_2}$ = constant, then

$$D_1 n_1 = D_2 n_2, \text{ or } \frac{n_1}{D_2} = \frac{n_2}{D_1}$$

Thus the stress-concentration factor for a $^3/_4$-in. specimen with 10 threads per inch may be found by testing a $1^7/_8$-in.-diameter specimen having 4 threads per inch, since $^3/_4 \times 10 = {}^{15}/_8 \times 4$.

In testing plaster specimens it is desirable to use fairly large specimens and to obtain a fairly large breaking load. The specimens were tested in bending, again using the Scott machine. The various sizes of specimens tested and the results obtained are given in Table 3. The stress-concentration factors for various diameters are shown in Fig. 8.

The curve which best represents the data is shown as a dotted curve. It is probably better to interpret the data by the straight line representing the average, and thus assume that the stress-concentration factors are about the same for all diameters of specimens having U.S.S. threads.

TABLE 3 TEST DATA ON U.S.S.-THREAD PLASTER SPECIMENS

Specimen	Actual no. threads per inch	Actual diameter, inches	Equivalent no. threads per in.	Equivalent diameter, in.	Breaking load, lb.	Stress-concentration factor
Q_1	St.*				243	
Q_2	4	$2^1/_2$	4	$2^1/_2$	171	1.42
R_1	St.				218	
R_2	4	$2^1/_2$	4	$2^1/_2$	148	1.47
S_1	St.				98	
S_2	4	2	6	1	72	1.36
T_1	St.				155	
T_2	5	$2^1/_2$	$2^1/_2$	5	119	1.30
V_1	St.				181	
V_2	$3^1/_3$	$2^1/_2$	$6^1/_2$	$1^1/_4$	134	1.35
W_1	St.				71	
W_2	$3^1/_3$	2	12	$^9/_{16}$	52	1.37
X_1	St.				242	
X_2	5	$2^1/_2$	$2^1/_2$	5	175	1.38
Y_1	St.				195	
Y_2	5	$2^1/_2$	$2^1/_2$	5	158	1.23
Z_1	St.				152	
Z_2	5	$2^1/_2$	$2^1/_2$	5	122	1.25
III_1	St.				168	
III_2	6	$2^1/_4$	2	$6^3/_4$	128	1.31
Average						1.35

* Standard specimen having no threads.

R. R. Moore[13] has performed a number of fatigue tests with U.S.S.-threaded specimens. His resulting stress-concentration factor of 1.19 for a $^1/_4$-in.-diameter specimen having 28 threads per inch, and of 1.38 for $^3/_8$-in.-diameter specimen having 24 threads per inch, have been plotted in Fig. 8.

He has also compared the effect of a continuous thread with the effect of a single groove of the same form. For $^1/_4$-in.—28, the thread is 3.58 times stronger in fatigue than the groove; for $^3/_8$-in.—24, the ratio is 1.76.

Similar tests were made using plaster-of-paris specimens cut with the same tool to the same root diameter. The following results were obtained:

V_1 = 150 lb. ($2^1/_4$ in. diam. 4 U.S.S. threads per inch)
V_2 = 105 lb. (one groove of same threaded form)

$$\frac{150}{105} = 1.43$$

VII_1 = 161 lb. ($2^1/_2$ in. diam. 4 U.S.S. threads per inch)
VII_2 = 121 lb. (one groove of same threaded form)

$$\frac{161}{121} = 1.33$$

Average = 1.38

These results are considerably lower than those obtained by R. R. Moore.

Fig. 9 shows a specimen having full U.S.S. threads and grooves

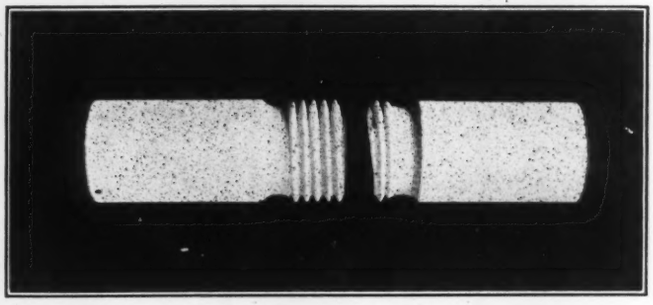

FIG. 9 SPECIMENS HAVING THREADS AND GROOVES

of $^1/_2$ in. radius at the thread ends. The grooves were of the same depth as the bottom of the threads. This combination of grooves and threads caused failure to occur in the threads and not at the thread endings, as is ordinarily the case. Thus the full strength of the threads was developed. Further work with thread-and-groove combinations probably would be valuable.

Conditions Governing Use of Hypoid Gears

HYPOID gears resemble spiral bevel gears in that they have curved teeth, but in the case of the Hypoid the axes are offset and the pinion is much larger in diameter. The spiral angle of the gear is less, while the spiral angle of the pinion is equal to or larger than the corresponding spiral bevel gear. Their principal advantages are silent operation and strength.

Gear teeth in general, when case-hardened, become thicker and shorter with a resulting shortening of the profile bearing contact. With Hypoid gears it is possible to overcome this difficulty by cutting the tooth bearing slightly heavier at the top and bottom than at the pitch line so that an even weight of profile is obtained after hardening. The lengthwise bearing can also be controlled and all bias bearing eliminated.

Hypoid gears are intended primarily for automotive work where the large production will warrant the necessary development work; it is not economical to manufacture in small quantities. Nearly all rear-axle gears are lapped to obtain smoothness, and this operation can be done efficiently on Hypoids because of the endwise sliding between tooth surfaces. With spiral bevel gears, it is possible to spoil a pair by excessive lapping, thus causing too great a confinement of the tooth action at the pitch line. The sliding motion of Hypoids, on the other hand, smooths the entire bearing surface of the profiles.

The reduction of the spiral angle on the gear results in a decreased normal tooth load for a given transmitted load, while the chief advantage of the enlarged pinion diameter is that a larger pinion shank is permitted. The added stiffness prevents concentration of the tooth load and permits the full utilization of a longer tooth bearing. In fact, for best operation the whole gear and bearing mounting should be designed with a view of minimum deflection, so that the pinion will not spring away from the gear. Adoption of the webless type of gear with suitable ribbing on the differential case and sufficient spread of the differential bearings will provide the necessary stiffness without much increase in cost.—F. E. McMullen in paper before the American Gear Manufacturers' Association, October 14–16, 1926.

[13] Moore, R. R., Effect of Grooves, Threads and Corrosion upon Fatigue of Metals, A.S.T.M. paper presented at Atlantic City, N. J., in June, 1926.

Modern Sash and Door Manufacturing

Materials Used—Cutting Sash and Door Parts from Rough Lumber—Machining Stiles, Rails, and Panels—Dowels—Assembling and Sanding

By SERN MADSEN,[1] CLINTON, IOWA

PRESENT-DAY sash-and-door manufacture involves many new problems brought about by increased competition, higher wages, changing architectural designs, and a constantly diminishing quality and quantity of suitable lumber. These conditions are being met by improved methods, changed construction, and highly specialized machinery.

The best way to approach this subject is through familiarity with the various members that make up sash and doors. Each piece must meet its own individual requirements and presents its own problems in manufacture. Figs. 1 and 2 show these members in their relative positions in the finished sash and doors, with the name of each indicated.

Cutting Sash and Door Parts

These various members must be cut from rough lumber. They may be produced solid or built up from glued strips covered with veneer. Rough cuttings for this purpose are commonly known as "cut stock." The production of this stock is a process which requires great care and judgment on the part of the sawyers in order to avoid waste.

Fortunately, sash and door cut stock can be cut simultaneously from the same lumber. Sash stock being narrower and shorter fits in well so as to avoid waste. Pieces too small for sash parts are reclaimed as core for veneered stock. Knots and shavings usually produce all the fuel needed to produce power and heat for the entire sash-and-door factory. Few industries are as fortunate in this respect.

The usual thicknesses of lumber used are $1^1/_8$ in., $1^3/_8$ in., and $1^3/_4$ in. Generally stock entering a factory is dressed $^1/_{32}$ in. thicker than these dimensions. Panel stock, usually resawed from thicker cuttings, is about $^1/_2$ in. to $^5/_8$ in. thick. Laminated, or glued-up, panels are also used extensively. Average dimensions of cut stock are about as follows although some other parts may be smaller.

Door rails	16 in. to 36 in. long by 3 in. to 18 in. wide
Door stiles	72 in. to 84 in. long by 3 in. to 8 in. wide
Sash rails and stiles	16 in. to 60 in. long by 2 in. to 5 in. wide

Most of the wooden doors are today made from white pine and fir. In fact, these are the only woods used extensively in the solid. Other kinds of wood are used almost exclusively in veneered doors, pine or fir being used as a core. Birch and oak are the leading hardwoods used, although nothing prevents use of any wood desired, as long as it is of size and texture to permit proper working.

The average cutting department has not made use of all the latest labor-saving devices such as electric lumber handlers, high-speed band saws, convenient saw guides, table stops, conveyors, etc. With convenient arrangement and modern equipment it is possible to cut up intelligently and economically as much as 25,000 ft. b.m. of lumber on one band rip saw and two cut-off saws during an eight-hour run. The average cut is much below this. One man with an electric lumber handler can keep three such outfits busy. Conveyors and other labor-saving conveniences greatly reduce the hand labor required. A number of factories are now making progress along these lines.

Differing from furniture and other allied plants, the sash-and-door factories rip their stock first and then cut to length. This procedure permits cutting out knots to best advantage to produce the longer lengths needed for door stiles. The wider rips are cut up for door stock and the narrower ones for sash stock. Edgings left over are later used for making smaller-size moldings.

The kind of soft pine used in sash-and-door manufacture has but little use in any other lines. The lumber has a great many large knots and has but little structural strength if any such knots are present. To produce usable dimension stock from such lumber is impractical and extravagant. By means of judicious cutting, door stock in sizes usable in sash and doors can be produced. The only other use for such lumber is for making boxes. Small quantities are marketed in this way. As a rule, the clear cuttings are too valuable for box material.

It should be noted here that the sash-and-door factories use a kind of lumber which, while ideal for this purpose, has but little use in any other way. In this respect they are doing their part in helping to conserve our nation's lumber supply.

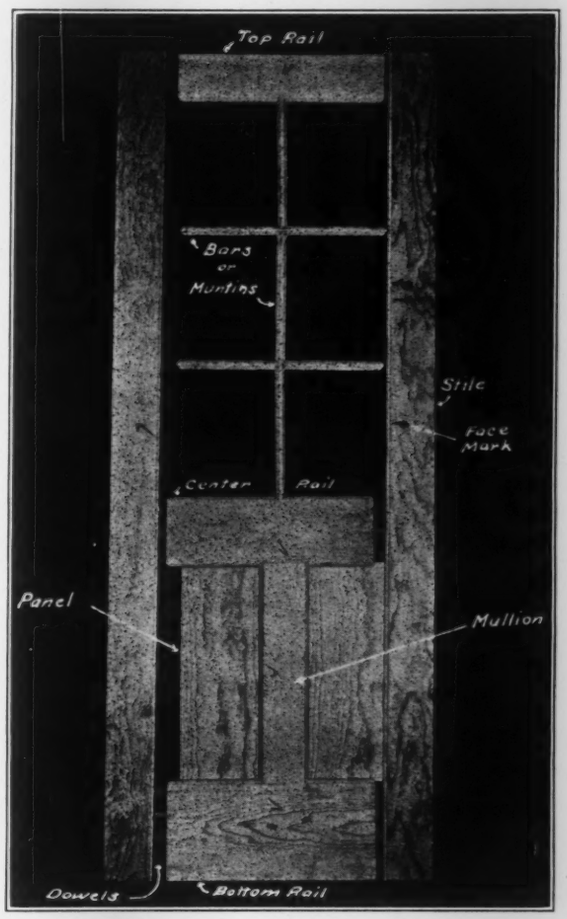

Fig. 1 Door Members

With the passing of the northern soft pine, the finest timber that ever grew, it was necessary to use western pine and fir. Already it has become necessary to conserve this supply to the utmost by working up even the lowest grades.

Veneer Stock

Within the past two years nearly every door factory has turned to an increased use of veneered construction, even in the softwood doors such as those of pine and fir. This makes possible the use of still lower grades of lumber, since clear stock is required only for edge strips and face veneer. The core blocks accumulate from the regular process of cutting; edge strips can be cut from narrower stock which is easier to get; and face veneer may be produced by resawing or by rotary cutting. By resawing, one clear $1^3/_8$-in. thick stile will produce six pieces of $^1/_8$-in. veneer, or enough for

[1] Mechanical Engineer, Curtis Cos., Inc. Mem. A.S.M.E.

Presented at the Wood Industries Division Meeting of the A.S.M.E., Chicago, November 26, 1926.

three veneered stiles, thus making the same amount of clear lumber produce three times as many doors. Rotary-cut veneer is undoubtedly the most economical to use, since it can be produced without waste of saw kerf from clear logs too short to produce marketable lumber.

Veneered construction is not new. It has been used for years in hardwood doors, for the reason that soft-pine core covered with hardwood veneer has many superior qualities not found in the solid stock. Chief of these are practical absence of shrinking and warping and the greater beauty of grain to be found only in veneered stock.

It is only recently that these advantages have been sought in the softwood doors. It is especially fortunate that the good qualities of veneered door stock fit in so well with the necessity of having to

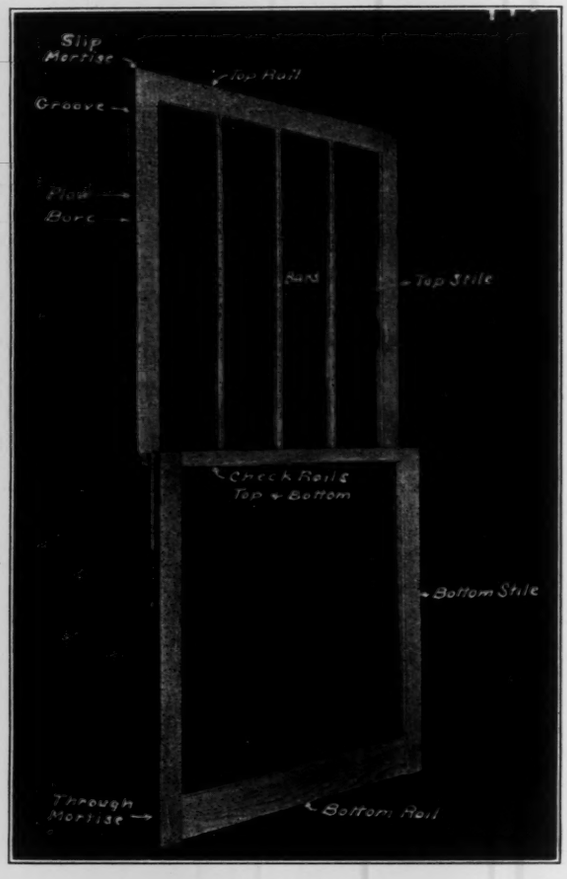

Fig. 2 Sash Members

use lower grades of lumber. Here at least is one place where the woodworking industry actually improves its product by meeting the demands of conservation.

The process of veneering is more or less familiar to all in the woodworking business. In making veneered door stock, the process is not much different from the usual methods, except in the more extensive and convenient equipment used. The core blocks are carefully ripped and dressed, usually with tongue and groove. Edge strips are dressed to match. Two or more rows of core blocks are generally assembled between two edge strips. The assembling is usually done on pans or tables covered with sheet iron. Glue is applied to the blocks and strips by means of rolls. Some still use hand power for this operation, but the more progressive plants apply the glue automatically as the blocks leave the sticking machines.

There is a wide diversity in the methods of clamping. Some use hand clamps, others power clamps and retainers, and still others use clamp-carrier machines, piling clamps, etc.

The glue used also varies extensively. Hot animal glue seems to be giving way to vegetable and casein glues. Other manufacturers have adopted waterproof glues for this purpose. There is room for much argument as to just what constitutes a waterproof glue. Many do not deserve the name.

The glued-up core and edge strips, when dry, are surfaced and the veneer faces applied. This process requires a powerful press and heavy retainers. Much ingenuity has been displayed in the various methods employed. If there is any place in the sash-and-door industry that we need standardized methods and equipment, it is in the gluing and veneering departments. There are practically as many different systems as there are factories. Perhaps one of the worst features of this phase of the industry is a general lack of uniformity in the goods produced. For this reason the veneering operations must be watched carefully and performed intelligently.

Here we find the difficult process of working with kiln-dried stock and wet glue. The control of moisture in the product is at present somewhat in the nature of guesswork. To apply dry veneer to wet core stock is to invite trouble. It seems that in the present stage of the art the best practice is to follow each process of gluing by a period of drying and seasoning. No machine work should be done on anything but thoroughly dried stock. This again brings up the

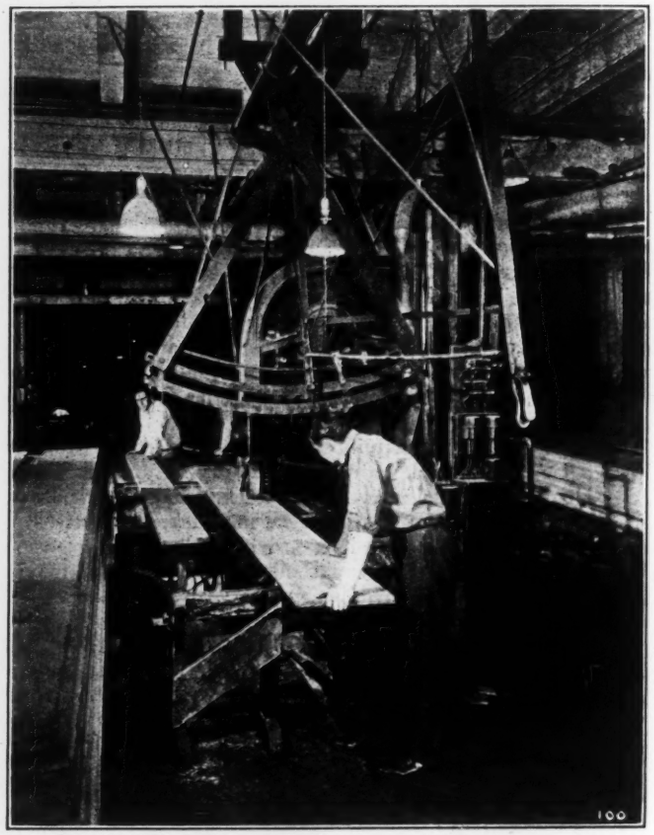

Fig. 3 Ripping Is the First Cutting Operation. The Load of Lumber at the Left Has Been Hauled in on a Roller Chain. Note Convenient Setting Lever for Guide

problem of making the cutters stand up in the hardened, dry glue. Perhaps some time all the troubles will be overcome.

We have digressed somewhat from the general subject of door manufacture in order to acquaint ourselves more clearly with the materials that enter into their construction. A few words about door construction are now in order.

Until about twenty years ago most doors were made with mortise-and-tenon joints. This requires that all door-rail stock must be from 8 in. to 10 in. longer than is now required for doweled construction. The use of hardwood dowels prevents this waste on all cross-members in the door. It has been found that the glued-dowel door actually has greater strength than the pinned-tenon door. The large glued surface of the dowels and the lessened danger of reduced contact due to shrinkage account for this. Perhaps this can be explained by saying that a tight-fitting dowel glued into a round hole is much less apt to loosen up than a wide tenon in a less perfect-fitting mortise. The presence of wooden pegs in the face of a tenoned door is also objectionable. Not only is the stock required for the tenon saved, but it is also possible to cut closer to the knots

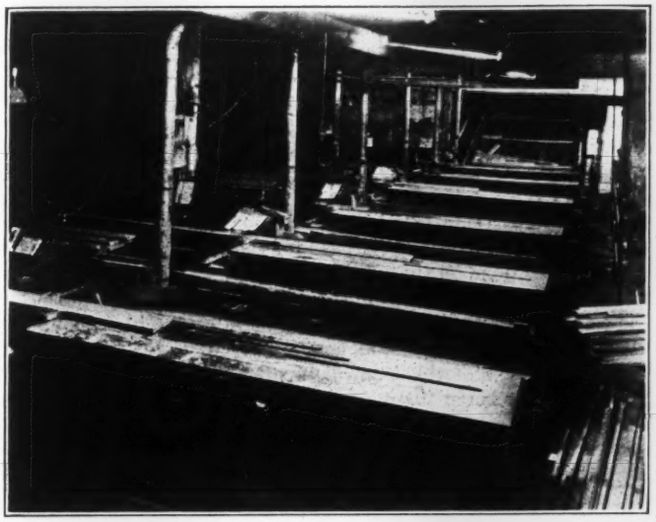

FIG. 4 TWO CUT-OFF SAWS RECEIVE STOCK FROM ONE RIP SAW. ROLLER CARRIAGE AND AUTOMATIC FINGER STOPS MAKE FAST CUTTING POSSIBLE. CUT STOCK SLIDES TO CONVEYOR WHICH CARRIES IT UP TO SORTING ROOM

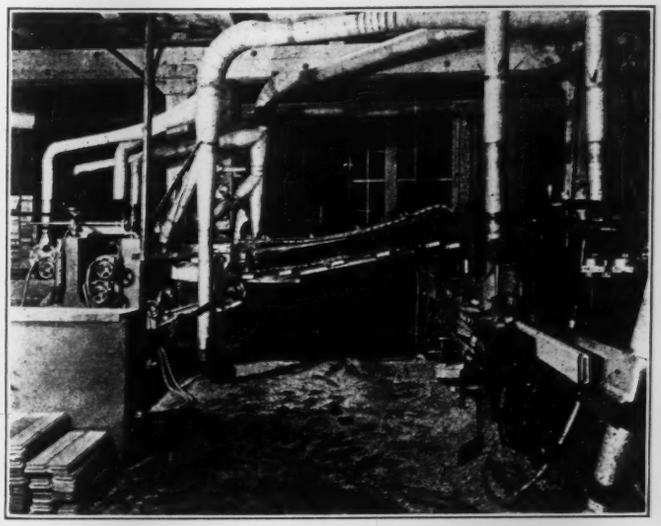

FIG. 7 SHOWING OPERATION OF TENONING AND STICKING RAILS PERFORMED BY ONE UNIT CONSISTING OF DOUBLE-END TENONER, AUTOMATIC FEEDER, AND "STRAIGHT LINE" STICKER

FIG. 5 SASH AND DOOR CUT STOCK IS REMOVED FROM CONVEYOR. SMALL BLOCKS FALL TO TURNTABLE WHERE SORTERS SEPARATE WASTE FROM STOCK USABLE FOR CORE. THE LATTER GOES UP TO THE CONVEYOR TO BINS

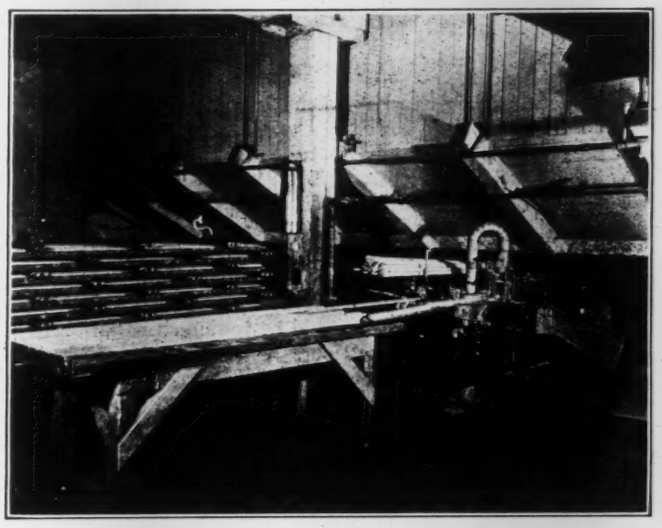

FIG. 8 A HIGHLY SPECIALIZED MACHINE WHICH RIPS, DRESSES, AND APPLIES GLUE TO CORE BLOCKS AND EDGE STRIPS. ASSEMBLER BUILDS UP CORE ON THE METAL-COVERED TABLE

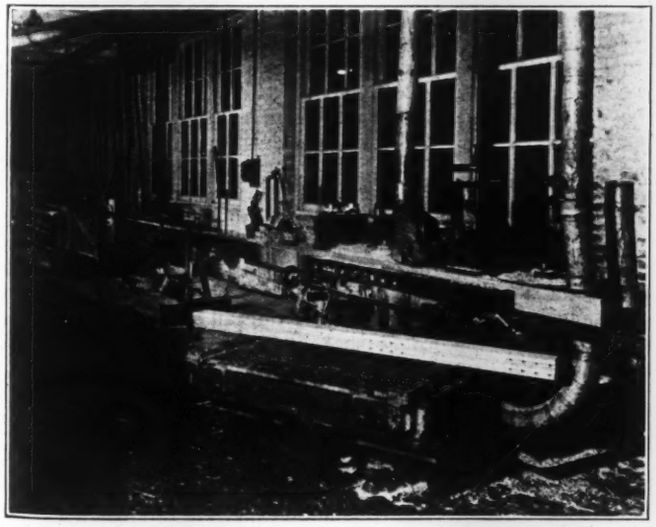

FIG. 6 THIS SHOWS REGULAR STILE-BORING MACHINE WITH AUTOMATIC FEEDER TO STICKER. THIS TYPE OF STICKER PRODUCES ABSOLUTELY STRAIGHT LINES

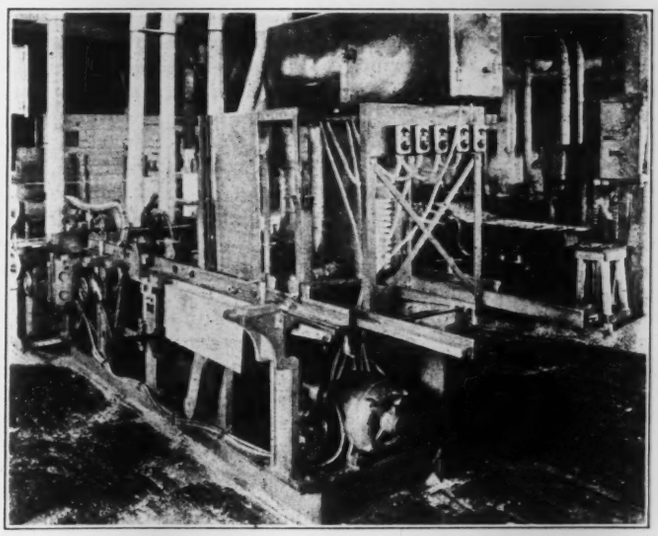

FIG. 9 AN AUTOMATIC MACHINE FOR MAKING SASH STILES AND RAILS. THIS UNIT WITH HOPPER FEED AND RUNNING RIGHTS AND LEFTS SIMULTANEOUSLY PERFORMS ALL OPERATIONS OF BORING AND DOUBLE-GROOVING FOR THE SASH CORD

in sawing cut stock for doweled door rails. Cross-grain impractical for a tenon is not so objectionable at the end of a rail held in place by dowels. Here again improved quality and conservation of materials go hand in hand.

Machining of Parts

The machining of parts preparatory to assembling is a procedure requiring great care. We are not dealing with a homogeneous material like metal, but one subject to shrinking and swelling, warping and twisting hard and soft grain, and a multitude of other eccentricities. It is essential to start with nominally dry materials and to maintain a temperature and humidity throughout the factory operations which will maintain a constant moisture content in the wood used. And last, but not least, these goods must be stored, transported, and installed in the home under variable conditions. It has been found by experience that maintaining 6 per cent to 10 per cent moisture content during manufacture best meets these requirements.

One of the first steps in machining is to surface all stock making up stiles and rails to an even thickness. This should preferably be done after the cut stock has had time to season following the cutting operation. The wood will then have equalized many undue stresses and have approached a fairly uniform moisture content. To surface to thickness under other conditions than when seasoned and ready to enter the factory for machining would defeat the purpose of this operation.

Door Stiles

The dry surfaced cut stock is taken first to a gang boring machine to bore the holes for the dowels. This is done on a machine which holds the stile in a perfectly flat, straight position between powerful jaws, while a set of drill bits bores all the necessary holes at one stroke. Machines are made to bore either rights or lefts. Although the holes are drilled in the center on the edge of the stile, it is highly important that all stock should be "faced:" that is, all operations shall be performed with the same side used as the face from which to make all measurements and machine set-ups. Except for this precaution there would be too much variation in the surface joints of the assembled door. Once a piece of stock passes its first operation, it has a mark upon it indicating which is the face side.

From the boring machine the stile passes through the "sticker," which dresses one edge and molds the other, forming the panel groove and ornamental molding so distinctive of the various types of doors. Through this machine the stock must be run as rights and lefts, this distinction being determined entirely by the "face mark" previously mentioned. If there is any special requirement in this operation, it is that all stiles which have been "stuck" must be produced absolutely straight. The old-style machines having roll feed will not produce straight stiles from bowed stock. With such machines all stock for stiles should be first jointed straight. Newer types of machines, which feed or propel the stock by gripping the sides (rather than the edges), will produce straight work. It is evident that crooked stiles can never be expected to produce straight, flat doors. Another inherent defect of wood must be overcome: many pieces of stock will have a twist or wind, and unless the sticker has feed works powerful enough to straighten such stock while passing the cutter heads, the sticking will not be done square with the face.

In the final door assembly, slight twist or wind can be fully overcome, provided all the dowel holes are bored true and parallel with the face, and the sticking of stiles is square with the face. Perhaps some day stiles will have each and every necessary machining operation performed in a single machine, with the stock held true and firm during all cuts, without once being shifted from the holding device until completed.

Door Rails

Cut stock for rails is surfaced like the stiles and passes at once to a double end-tenoning machine. Since the coming of the electric motor this machine has been highly specialized, using often as many as nine to eleven individual motors. In this machine, as in most modern door machines, the motors have ball bearings and the motor shaft also carries the cutter head.

In the tenoning machine the rails are cut accurately to length and coped out on the ends to fit the sticking on the stiles. This machine exerts a reasonable amount of pressure, but cannot completely straighten out wide rails which have become warped, cupped, or twisted. This of course makes accurate machining the more difficult. Built-up or veneered stock overcomes this objection to a large extent. An automatic marker puts a face mark on the stock as it passes through the tenoner.

The next operation is sticking. Either one or both edges are molded, accordingly as the rails are for the center or the end of the door. This is done on the same (or a similar) machine as that used for the stiles.

The rails now pass to the doweling operation. This is done on a specialized machine which has a hopper feed, works on both ends simultaneously, and which automatically performs in three stages of advance the three distinct operations of boring all the dowel holes, squirting glue into these holes, and finally inserting all the dowels accurately. In this machine, as in most others, a reasonable amount of pressure is exerted so as to hold the stock flat and free from wind.

As stated in connection with the making of stiles, we may some day see all these various operations performed at one time in a highly specialized machine. The present objection to such machines is that a breakdown or failure of one operation will put the entire machine out of use. The woodworking industry is surely coming to automatic machines, much as the metal trades already have. The principal difficulty seems to be the multiplicity of designs and sizes which present-day styles of architecture require. Until we can make one-size, one-design doors we shall never attain our desires in the way of full-automatic machines.

Panels

As briefly mentioned, panels may be solid or veneered. The solid panels are run through a double-end panel raiser which cuts and thins down the edges so as to fit the grooves in the stiles and rails. One pass through the machine cuts the two ends and a second pass cuts the sides, the machine being adjustable as to width.

Laminated panels may be either three- or five-ply, built up of as many layers of rotary-cut veneer, each alternate course having its grain at right angles to those adjoining. This kind of panel has the edges chamfered only for ease of assembling. They appear in the door as an entirely flat surface.

Dowels

The dowels used are made of harder woods such as oak, birch, and maple, although yellow pine and gum may be used at times. The size varies from $1/2$ in. to $3/4$ in. in diameter and up to about 5 in. in length. There are many fancy ideas about dowels. Some are machined with "necks" cut near the ends; some have spiral grooves their entire length; and some have wedges cut at the ends, so arranged as to spread the end of the dowel when driven to the bottom of the hole. Opinions differ as to the merits of each type, but usually actual practice defeats the theoretical advantages claimed for each type. The plain, straight, round dowel with a small, lengthwise groove and with ends chamfered to facilitate assembly, seems to be about as good as any. After all, it is glued-surface contact with the hole that counts. Effort to add some extra holding element indicates lack of faith in the glue used. It is quite important that the dowel be provided with a longitudinal groove to permit escape of entrapped air as the dowel is driven. Air entrapped ahead of a dowel may split the rail or stile. When properly assembled, the stress on a dowel is almost entirely tension. But little bending stress is present if the joint between the rail and stile fits up well. Some tests have indicated that an ordinary $1/2$-in. dowel will resist about 800 lb. tensile stress.

The type of glue used varies, but usually animal or hide glue is used for holding the dowels. Vegetable or casein glue is used extensively for veneering operations, and sometimes also for dowels.

Assembling

There are two methods of assembling doors in common use. One consists of arranging the parts on edge, driving the dowels partly by hand, and later placing the door in the power clamp. In the other method the parts are laid together in the clamp and squeezed up

as soon as properly arranged. Glue for the ends of dowels entering the stiles is supplied by a machine in which a nozzle enters each hole and squirts in a measured quantity of glue. When securely clamped, parts which have been machined accurately will draw up so as to overcome slight warp and twist of the various members.

SANDING

After the doors are removed from the clamp, they are set aside for a few hours, after which they are run through sanding machines. The use of a machine which sands both surfaces in one pass is growing in favor. Usually three-drum machines are used, the double machine having six. Machines having four drums for sanding each surface have recently come on the market.

Excepting special doors requiring hand operations, the sanding operation completes the door and it is ready for shipment to the user.

SASH

In general, the process of making sash parts are similar to those just described for doors. In sash construction, through tenons and mortises are used. The parts are assembled and held by driving steel dowel pins, no glue being used.

The first operation consists of trimming and tenoning the ends of stiles and rails. The rails alone have tenons and the stiles have slots or mortised ends. The chain-saw mortiser is generally used to cut the mortise to receive the tenons of the lower rail.

After the machining of the ends of the stock, the next operation is sticking. The stiles of check-rail sash require the additional operations of boring a hole and cutting of grooves to receive the sash cord. It is possible to combine many of these operations into one machine, but those on the market at present are all single-purpose machines.

When the millenium has arrived, all operations on each piece of sash stock will be performed on one machine, and the completed sash will be assembled, clamped, and pinned on a secon achine which delivers it to a third or sanding machine to finish the woodworking operations.

The subsequent operations of inserting the glass, driving the points, and applying the putty will undoubtedly continue to be done by hand. The diversity of sizes of sash, as in the case of doors, stands as a hindrance and a challenge to the machine designer who would attempt to make full-automatic machines for their production.

Until recent years the entire woodworking trade has been conducted on an unscientific basis. With the research work now going on, and the attention given by practical engineers, the whole industry, including sash-and-door manufacture, is gradually stepping up alongside the leading industries of our time.

The Value of Paint Primers in Protecting Wood

Measuring the Water Resistance of Coatings—Description of Coatings Tested—Results of Tests of Priming Coats

BY M. E. DUNLAP,[1] MADISON, WIS.

IN MANUFACTURING processes utilizing wood it is frequently desirable to protect that material temporarily from moisture changes and from the resulting changes in shape and dimensions. Automobile wheels, for example, are generally made at factories at some distance from the automobile assembling plants, and they may remain for a considerable period of time in an unfinished condition, during shipment or during storage, before the final painting. There has been a demand for a quick-drying and effective coating material which could be applied to the wheels to afford protection against moisture changes until they could be finally finished. Attempts have been made to fill the need by the use of what have been termed "primers." These are usually drying oils with or without thinners; sometimes they contain varnish resins. Any material used for the purpose must of course be of such character that it will not interfere with the subsequent finishing of the wood.

Presumably because penetration of the primer into the wood is a property greatly sought, materials used are frequently very thin-bodied. A popular conception of priming that is also taken into account is that they seal up the pores or openings in the wood and thus prevent the entrance of moisture.

A number of priming materials have been tested at the Forest Products Laboratory, along with other coatings, to determine to what extent they were effective in preventing the passage of moisture into or out of wood. Their ability to reduce the rate of moisture changes in these tests has been termed their moisture-proofing efficiency.

MEASURING THE WATER RESISTANCE OF COATINGS

Moisture-proofing efficiency, as here considered, is determined by subjecting standard dry test panels to high humidity and measuring the amount of moisture absorbed (increase in weight) during a given period of time. The difference between the amounts absorbed by a coated and an uncoated panel expressed as a percentage of the amount absorbed by the uncoated panel, is taken as a numerical expression of the moisture-proofing efficiency. The more effective the coating, the higher will be the efficiency percentage. In these experiments yellow birch is ordinarily used in pieces measuring $^5/_8$ in. × 4 in. × 8 in., with the edges rounded to facilitate coating. The specimens are held in storage under a constant humidity of 60 per cent, which keeps them at a moisture content fairly close to an average air-dry condition.

To prepare specimens for test they are removed from the storage room, coated with the material to be tested, and returned to the same room for a final conditioning period of at least two weeks. After this period the panels are weighed, exposed to a humidity of 95 to 100 per cent for two weeks, and again weighed. The gain in weight per unit of surface during the two weeks is used to determine the moisture-proofing value of the coating. The test is purely empirical and it does not give information on the permanence of the effect, but long experience with it has shown that it is very useful. Other species than birch have been tried, to see to what extent the kind of wood affected the results of the test. It was found that variations due to species were insignificant, but since birch has proved to be a satisfactory wood for the purpose and easy to obtain it has been retained as the standard.

The test is subject to some inaccuracies in connection with the application of the coating and the maintenance of an even humidity and temperature during the testing period. It is quite difficult to apply coatings to wood and do it in exactly the same way every time. Changes in temperature causing even slight fluctuations in humidity in the testing compartment sometimes affect the results. In the present stage of development, therefore, the test values obtained cannot be considered absolutely exact. They do indicate with fair accuracy, however, the relative moisture-proofing effectiveness of different materials.

DESCRIPTION OF COATINGS

Linseed oil, which is often used as a primer, was included in the tests here reported. The specimen was of the commercial grade known as boiled linseed oil. This material is designated by the letter A in Fig. 1.

Two oils were furnished for testing which were apparently mineral oils of a very pure grade. They were colorless and odorless and rather light-bodied. These are lettered B and C in Fig. 1.

Thirteen commercial primers were tested and are referred to by

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Presented at the Wood Industries Division Meeting of the A.S.M.E., Chicago, November 26, 1926.

the letters from D to P, inclusive, in Fig. 2. The materials were prepared particularly for temporary moisture-proofing purposes. They probably consisted of drying oils with or without gums or resins, and were sometimes thinned to aid in penetration of the wood.

Wood-floor preservatives are in nature somewhat similar to primers and are therefore included in this report. They usually consist of a drying oil thinned with kerosene, naphtha, or some other thinner. This group of three materials is lettered R, S, and T in Fig. 3.

The letter U (Fig. 3) represents a somewhat different material. It is a solution which when applied to wood does not change its appearance, but nevertheless seems to have a marked retardant effect upon atmospheric moisture absorption. It is designed for moisture-proofing textiles, and when applied to such materials provides a surface that is not wetted by water.

The varnish designated by V (Fig. 2) was a good grade of spar varnish purchased from a local dealer.

Tests of Priming Coats

For many years when a problem of moisture-proofing of wood presented itself, the "first aid" was usually a coat of linseed oil. It was believed to be a positive check to moisture absorption. Nevertheless in our tests linseed oil has never demonstrated itself an effective moisture-proofer, although tested repeatedly. Fig. 1 shows the low relative efficiency of linseed oil as applied to two sets of test panels. The mineral oils with the moderately high efficiencies indicated in Fig. 1 were thin and almost colorless. They have been suggested as moisture-proofers. They showed a fair degree of moisture resistance, but it is uncertain whether finishes could be applied over them successfully.

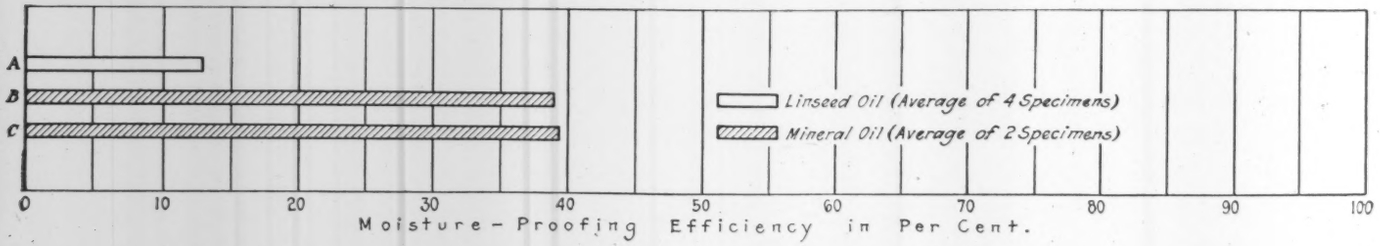

FIG. 1 MOISTURE-PROOFING EFFICIENCY OF LINSEED OIL AND MINERAL OILS APPLIED BY SOAKING 24 HOURS

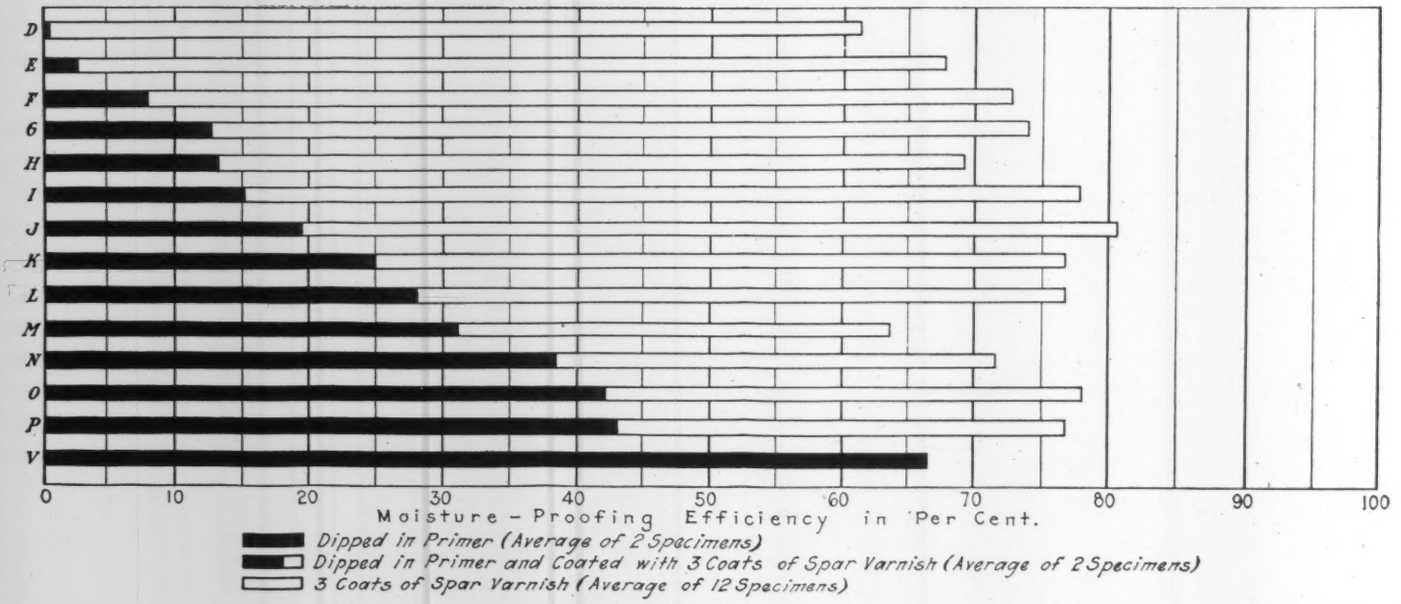

FIG. 2 MOISTURE-PROOFING EFFICIENCY OF PRIMERS ALONE AND WHEN SUBSEQUENTLY COATED WITH THREE BRUSH COATS OF SPAR VARNISH

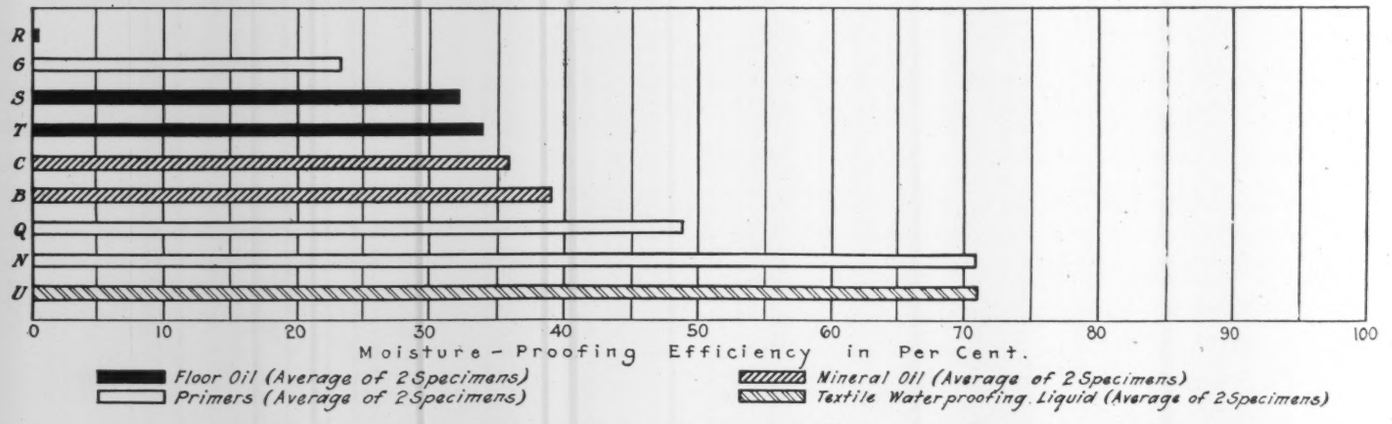

FIG. 3 MOISTURE-PROOFING EFFICIENCY OF SEVERAL WATERPROOFING MATERIALS IN THREE COATS BY BRUSHING

Fig. 2 shows the results of a test of the 13 commercial primers (D to P) when used alone in one coat and also when three coats of varnish were applied over each. It will be noted that when used alone the primers vary considerably in their moisture-proofing value; that is, from a percentage almost too small to measure to a little over 40 per cent. Those having a heavy consistency or body gave better results than the thin materials. It appears from our moisture-proofing studies in general that it is necessary to have a definite coating over the surface to retard moisture changes. Attempts to "plug up the pores" alone have not been effective. Wood absorbs or gives off moisture from all exposed surfaces, and not only from pores or other openings.

The effect of the primers on the ultimate moisture-proofing value of the coating when subsequent coats of varnish are applied would seem (Fig. 2) to be rather hard to predict. Although the primer itself may have a good moisture-proofing effect, it does not necessarily follow that the efficiency of the complete finish will be correspondingly higher than finishes over less efficient primers. A wide range in the efficiencies of the primers alone is indicated in Fig. 2, but relatively slight differences in the efficiency of the completed finishes.

The added moisture-resisting value of each coat in a succession of coatings decreases as the number of coats increases. In the case of the first two coats, if the first coat has an efficiency of 50 per cent, two coats will not prevent all changes of moisture but will have an efficiency of something less than 100 per cent. Experiments with finishes in which as many as twelve coats of varnish were applied failed to produce a perfect efficiency.

Fig. 3 gives results of brushing on three coats of several materials, including some used especially as primers for moisture-proofing purposes. Of the three oils (R, S, and T) for protecting floors two greatly exceeded the other in moisture resistance, although the efficiency shown was not very high. Mineral oils (B and C) are again shown in Fig. 3, as in Fig. 1, to be only moderately effective. Fig. 3 also shows the high efficiency of a black-pigmented primer Q and of an unpigmented waterproofing material U. The latter does not alter the appearance of the wood and would possibly be quite satisfactory for such a use as the protection of drawer sides against swelling. It is not known whether the material U can be finished over successfully. The three coats of primer N gave slightly better efficiency than three coats of spar varnish used as a standard in Fig. 2. This was a rather heavy-bodied primer.

Because of the wide variation that has been shown to exist in the moisture-proofing efficiency of different primers, one to be used on important work should be tested first to determine whether it will accomplish the desired purpose. Some have been found of such low effectiveness that their use would accomplish very little in the way of preventing the shrinking and swelling of wood. Others, although far from perfect, would probably meet the needs in cases where moderate protection only is required. In none of the Forest Products Laboratory tests has a coating of any kind been found that is 100 per cent efficient. The nearest approach thus far has been about 98 per cent, but this efficiency was shown by a coating of limited utility. It would not be at all satisfactory as a primer on wood to be stored or shipped in an unfinished condition.

German Steel Wage Rates Low

WAGES paid in the German iron and steel industry average from 25 to 50 per cent of those paid in the American industry. This is shown by a study made by J. C. Bowen, chief statistician, Bureau of Labor Statistics, Department of Labor. It is the second and final survey made by Mr. Bowen regarding the iron and steel industry abroad.

While virtually all of the American workers in the iron and steel industry are on an 8-hr. basis, most of those in the German industry are on a 10-hr. basis, except as to the blast-furnace department. For this reason the figures given to show American wages are based on a theoretical 10-hr. day with the exception of the blast-furnace department, with the following result:

	German (Maximum Wage)	American (Average Wage)	Per Cent of American Wage over German
Blast Furnace			
Blower	$2.33	$ 7.21	209
Keeper	2.07	4.61	123
Blooming Mill			
Roller	3.99	14.98	275
Shearman	2.12	8.12	283
Laborer	2.27	4.51	99
Plate Mill			
Roller	3.71	13.64	268
Shearman	2.98	7.83	163
Bar Mill			
Roller	5.52	17.00	208
Heater	4.57	9.54	109
Laborers	2.07	4.11	98

Nearly all wage earners in the metal industries of Germany are members of labor organizations and practically all of the work done by them is covered by agreement between employers and the union.

In Germany, piece workers work at so-called "accord" rates; that is, piece rates arrived at by accord agreements and established in each plant govern the work done there. Mr. Bowen explains that the whole system of wage rates in Germany is very puzzling to an American. For instance, as shown by the agreement for the Bochum district, all iron and steel workers in the district are, for wage purposes, divided into six purpose groups. Within the group the wage rate is determined by the age of the worker without regard to his ability provided he is employed in one of the occupations covered by the group. Except in one group, workers over 21 years of age have a nominal time rate per hour, but since about 85 per cent are piece workers, the time rate has little significance except in the case of those not yet 21, most of whom are time workers. The question, then, is to arrive at piece-work rates and earnings.

If a man over 21 does piece work and produces as much as he did at the time rate he will earn 15 per cent more; that is, his daily time rate for piece work is 15 per cent above the rate for time work. The same man with a time rate of 18.6c. per hour has a basic piece rate of 21.3c. the money conversion into United States currency being made at the par rate of 23.8c. per gold mark and 0.238c. per pfennig. This advance of 15 per cent is given to make piece work more acceptable.

No mention is made in any of the agreements shown of this additional 15 per cent but it was specified in the previous agreement with the district and still is accepted by common consent. Individual piece rates are worked out in conferences between the employer and workers' council. Piece rates may be determined from the man's production on a time rate over a certain period or may be based upon piece rates previously determined for others.

The semi-skilled labor in group 2, entitled to 13.8c per hr. for time work, has a basic hourly rate for piece work of 15.9c but on piece work he actually earns on an average from 16.2c. to 17.1c. per hr. The semi-skilled trained workers in group 3 have a time rate of 14.8c. per hr., an accord basis of 17c. and actually earn from 17.4c. to 17.9c. per hr. The skilled-trained workers in group 4 have a time rate of 16.7c. and accord rate of 19.2c. and actually earn from 19.2c. to 20.5c. per hr. In group 5, that of better skilled trained workers, there is a time rate of 17.6c. for men over 21, an accord base rate of 21.3c. and actual earnings of from 21.4c. to 22.6c. per hr.

Group 6 has a time rate of 18.6c., an accord rate of 21.3c. and earnings from 22.2c. to 25c. per hr. Men of the wage figures quoted or referred to include family allowances paid to married men in addition to their regular wages. When the employee has a wife he is paid 0.238c. per hour, and 0.476c. more per hour for each child under 14. Married men are protected by law against dismissal because of this additional wage and it is stated that this law is very generally obeyed. From the wages of the workers, deductions are made to cover taxes and sickness, accidents and unemployment insurance. Taxes take from 5 to 10 per cent of the wages, depending on the income and the family dependent on the worker. (*The Iron Age*, November 18, 1926, pp. 1411–1412.)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICAL ENGINEERING

The Gas-Starter System for Aircraft Engines

THE gas-starter system of starting an aero engine consists of charging cylinders and induction pipes with a combustible gasoline-air mixture by means of a small power-driven compressor unit, which pumps the mixture direct into the cylinders through non-return valves which are fitted in them for the purpose. The pressure under which the mixture is introduced is sufficient to cause the crankshaft to revolve, and after a few revolutions, when charging may be considered to be complete, the mixture is fired by switching on the spark from the auxiliary magneto (except when the engine is fitted with battery and coil ignition) which is connected to the distributor of the main magneto in the manner usual for hand-starter magnetos. The main engine then picks up from its own carburetors and ignition, and the starter is switched off.

To provide for the introduction of the mixture into the cylinders in the order of the firing sequence of the engine and at the correct point of the stroke, a mixture distributor forms a necessary component of the system, and the rotor of this is geared to the engine and runs at camshaft speed.

The starter described in this publication is the Bristol unit, which comprises a small single-cylinder two-stroke engine of the four-port type, the crankcase of which also carries the compressor cylinder. The two connecting rods for the two cylinders work side by side on a common crankpin, the stroke being $2^1/_2$ in. Both cylinders have a bore of 3 in. The unit is self-contained, possessing its own fuel tank, magneto, carburetor, silencer, and starting gear, and is compactly arranged on an aluminum base. Cooling is by a fan, incorporated in the flywheel, which delivers a current of air around the power cylinder and makes possible sustained running without overheating. The initial spark for starting the main engine is provided by the magneto on the starter, which is a two-brush model with the brushes set 180 deg. apart. The current from the brush which is not used for the ignition of the two-stroke is led to the main magneto distributor as mentioned above. Two types of starting gear may be used: one a ratchet and quadrant, and the other a crank handle.

The mixture from the compressor cylinder is carried to a rotary distributor valve the function of which is to pass it to the main engine cylinders in the order in which they fire. Steel pipes connect the delivery ports on the distributor with the cylinders, and the mixture enters the cylinders by spring-loaded non-return valves which open under a pressure of not less than 16 lb. per sq. in. Each make of engine has its own distributor, and though the working principle remains the same throughout, the models differ slightly in design and operation. (*Air Ministry, Air Publication*, no. 1181, Oct., 1925, 42 pp., several sheets of drawings, *dp*)

AERONAUTICS

The British Aircraft Industry

SMALL AIRPLANES

THERE are now in Great Britain six officially approved and state-aided clubs, one of the purposes of which is to teach men wishing to learn to fly. The Air Ministry who were in a difficulty as to the type of machine to authorize for these clubs, has now adopted the DeHaviland "Moth" for this purpose. This machine is fitted with the Cirrus 27–65 hp. air-cooled engine. Fully loaded it weighs over 1300 lb. and has just over 30 hp. per person carried. A check made by the engine makers over the maintenance and repair costs of 200,000 miles running has, they state, shown that the average cost of every engine expense other than fuel and oil has not exceeded a farthing ($^1/_2$ cent) a mile, and that from 300 to 400 hours can be run between overhauls.

BRITISH PRECAUTIONS AGAINST FIRE IN THE AIR

In large multi-engined craft the engine is invariably placed in the center of the cab between the wings, and the gasoline-supply tanks usually in the top wing. The only connection between the two is the actual feed pipe. This has to conform to several strict Government requirements, and in any case, owing to the rush of air through the wings, there is in effect an impassable barrier between the engine and the tanks, in addition to the actual distance. Thus should any extraneous flame arise in the engine nacelle it has nothing to feed upon and cannot reach anything inflammable. The same principle of placing the main fuel supply in the top wing is also adopted in many single-engined aircraft, and though the protrusion of the tank may mean some loss of aerodynamic efficiency, the sacrifice is more than justified by the elimination of the fire risk.

Strict regulations are laid down in regard to placing the fuel supply in the fuselage itself when it is desired, and in regard to the electrical installation. Among other things, it is provided that no fuel pipe may pass within 4 in. of a magneto or an exhaust pipe, and the latter must be reasonably free from the possibility of leakage and the discharges must be so arranged that they cannot impinge upon wires, struts, or other structural components.

NAPIER-LION AERO ENGINES

These engines are very extensively used. Among others in the service of Imperial Airways alone 2,000,000 of miles have now been run. The Mark V engine is today tested out by the makers on the basis of a rating of 470 hp., though it is actually rated at 450 hp. for a dry weight of 940 lb. For military use compression ratio is 5.8 to 1, but as the civil-aviation engine is required for commercial reasons to run on a gasoline of lower grade than aviation spirit, it has a compression ratio of 5 to 1, and is rated at 425 hp. at 2000 r.p.m. with a maximum of 460 hp. at 2200 r.p.m. The same unit, however, can be boosted up into a high-speed short-lived racing engine such as was used in the British Schneider Cup seaplanes of last year, 700 hp. at 270 r.p.m. for a dry weight of 700 lb.

Lengthy experiment upon metals, a meticulously minute system of inspection in the workshops, close attention to machine-shop finish, and a standard which few motor-car manufacturers ever consider, alone enable the engine to be pushed successfully to such a point. Aero-engine construction is, in fact, in a class of its own, and so exacting are its requirements that every toolmark must be taken out of any important part lest it should prove the first cause of breakdown of the unit concerned. This provides some explanation of the cost of aircraft engines. Another indication of the high standard today required in British engines is afforded by a comparison of the weight of some of the parts in the rough state as compared with the finished component. The master connecting rod, for instance, starts with a weight of $24^1/_2$ lb., and after no fewer than 75 operations ends up at $5^1/_4$ lb.; the cylinder is even heavier, for it starts at 100 lb. and when finished is only 10 lb., complete with water jacket. It is subjected to 50 different operations, but the crankcase, which is reduced from 150 lb. weight to 90 lb., requires 80 operations.

Even before the material is received at the factory it has already been approved by the inspectors of the Air Ministry, but, notwithstanding this, every main component in its rough state is subjected to chemical and physical tests before being worked upon, a small extension or test piece left on the rough part being stamped and then cut off in order to prove by test that the metal in every way is up to the required specification. It is only by such methods that the practical immunity of the aero engine from mechanical failure is secured, and there is probably no piece of machinery today which demands or receives such minute inspection throughout its manufacture. A large amount of research work has been had to be

carried out upon suitable steels and wire for valve springs, the stressing of which has largely increased with the greater speed of the engine. When the Lion engine was first produced failures of valve springs were not unknown; today it is a most unusual occurrence for this component to give any trouble. Similarly, point after point in the original engine has been the subject of continual experiment and development, until today it is probably correct to say that the standard Mark V engine has ceased to be an ideal to be reached, but rather a completed unit from which to make another jump forward. The standard Napier Lion has now completed 742 hr. under official British Government type test, and all the recent tests have been at 104 hr. duration, the last hour being at full throttle. This engine, the Series V, has been type-tested at a rating of 470 b.hp. and also at a rating of 500 b.hp., the speed for the latter power being 2250 r.p.m.

Unfortunately the conditions of secrecy imposed by the British Air Ministry on much present development prevent the full measure of enterprise of the British aero-engine manufacturer from being indicated, but some achievements may be briefly referred to. One is the Lion VI, which is a successful direct-drive counterpart of the Mark V geared engine, and another Lion, the Mark VIII, has been developed and has passed the British Air Ministry type test as a direct-drive unit giving 525 hp. at 2350 hr., with a compression ratio of 6.25 to 1. This is definitely a Service engine and was seen in public for the first time at the Royal Air Force display in July as the power unit of the Avro Avenger and the Gloucester Gorcock, both high-performance single-seater military fighters. Then there is the Lioness, which is in reality a standard Lion inverted and adapted to work in that position, with the object of providing the pilot of an airplane with a better view. The engine has passed all its type tests, but so far it has not been made use of by the aircraft designer, though inverted engines have been tried out in other countries. Actually the inverted Lion has ceased to be an engine problem, and it would be of interest to see to what extent the narrower section possible along the top of the nose of the fuselage with the engine in this position improves an aircraft from a fighting point of view.

The next stage in the development of the Lion impinges very closely upon the secret side of aero-engine progress, and is concerned with the supercharging of Mark V, Mark VI, and the Lioness, the necessity for which is becoming more and more urgent with the need of defending aircraft to be able to climb rapidly to the height of the hostile raiders and then operate as nearly as possible on ground-level conditions. All that can be said under this head is that the supercharger used on the Lion engines is of the turbine type, working at an extremely high rate of revolutions under the force of the exhaust gases.

Fuel-consumption figures for the standard Lion are returned at $29^3/_8$ gal. per hr. at full throttle, but at cruising speed the consumption, depending upon the work the engine is called upon to perform, has been proved to range from about 16 to 26 gal. per hr., with an oil consumption of a little less than a gallon an hour. (Symposium in *The Times Trade and Engineering Supplement*, vol. 19, no. 432, Oct. 16, 1926, pp. 117–119, *gd*)

The Meyers "Midget"

DESCRIPTION of a 30-hp. light plane developed during the past year. It is a very small single-seater biplane with a Bristol Cherub III engine of 30 hp. The wings, upper and lower, are tapered in both plan form and thickness. The underplane bay is single and there is no underplane wire bracing.

The fuselage is formed of birch veneer bulkheads with a narrow veneer side, forming a girder from front to rear about one-third the actual depth of the fuselage. Spruce longerons of L-section are arranged on each side of this plywood girder, and these form the main structural members of the fuselage. Spruce fairing strips are arranged on both the upper and lower sides of the fuselage, this providing fairing above and below the fuselage proper, giving an oval section. These fairing strips are also placed so as to take part of the vertical stresses. A double plywood and veneer girder runs from under the seat, through the bottom and center of the fuselage, to the rear of the bulkhead back of the engine. This carries the pilot's seat and the controls, and also provides a mounting of the lower wing and two cross-bracing members of the undercarriage structure, in addition to a foundation for certain cross-bracing members of the engine mount at the front end.

No tests have been carried out upon the plane to determine figures of performance. It is said, however, that the plane handles well and that it has a speed of about 100 m.p.h. The detailed dimensions are given in the original article. (*Aviation*, vol. 21, no. 14, October 4, 1926, pp. 592 and 594, 1 fig., *d*)

Remarkable Achievement of Soviet Aviation

A YOUNG Red Army aviator, in a Soviet plane fitted with new motors made in Soviet factories, has completed a three-day flight over western Europe and returned to Moscow, making landings at the principal capitals. He covered 4167 miles and his flying time was 34 hr., 26 min., making an average of 121 m.p.h. The airplane was a machine made for ordinary postal service, with a motor of 450 hp. manufactured after the design of engineer A. N. Tupolev.

The aviator hopped off from the Trotsky airdrome, Moscow, accompanied by his mechanic at 3:27 a.m., Aug. 31. The first stop, Koenigsberg, Germany, 733 miles was made in 5 hr., 52 min. Another hop to Berlin, 360 miles, was made in 3 hr. 17 min., and the third leg to Paris, 578 miles, took 5 hr. 54 min.

The itinerary of the second day, Paris to Rome to Vienna, called for the passing of the French Alps, the Italian Apennines, and the Italian Alps under rather difficult conditions. The flight from Paris to Rome, 745 miles, was made in 5 hr. 43 min., and that from Rome to Vienna, 534 miles, in 4 hr. 10 min.

On the third day a planned stop at Prague was abandoned because of a thick fog. Warsaw, 472 miles, was reached in 4 hr. 10 min., and the home flight to Moscow, 745 miles, was made in 5 hr. 20 min. on September 3, the aviators having been absent 62 hr. 52 min.

Airplane construction in the Soviet Union was begun less than two years ago. The first Soviet-made airplane motors were tried out in the summer of 1925, one of them achieving a flight to Peking and Tokio. (*Russian Review*, vol. 4, no. 12, Oct., 1926, pp. 183, *g*)

ELECTRICAL ENGINEERING

The Bisynchronous Motor

ASSUME that by an auxiliary motor the inductor of an asynchronous motor is boosted up to a speed twice that of synchronism. In that event the velocity of the rotating field of the rotor is equal in absolute magnitude to the velocity of the rotating field of the stator, while the frequency of current in the stator is the same as in the rotor. This circumstance suggests the possibility that they may be synchronized and as a matter of fact, if, at the moment when synchronism is attained, one should apply to the rotor a voltage at least equal in magnitude and contrary in sign to the electromotive force induced in the rotor, there will result a current which in sign is opposed to that which would have been induced in the rotor if the latter were closed on itself. Now, if the operation of the device is above synchronism and the rotor is operated by an auxiliary motor, the couple has a sign contrary to that obtained when the operation is below synchronism; if, however, at the instant when bisynchronism is attained, there be applied an electromotive force at least equal and in sign contrary to the induced electromotive force, the couple changes its sign and becomes a motor again.

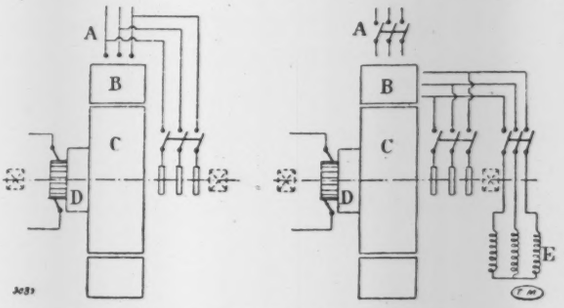

FIG. 1 BISYNCHRONOUS MOTOR IN PARALLEL

FIG. 2 BISYNCHRONOUS MOTOR IN SERIES

(*A*, three-phase bars; *B*, stator; *C*, rotor; *D*, d.c. starting motor: *E*, reactance.)

The device embodying the theory as stated above may be actually constructed, and in two types depending on whether it is operated in series or in parallel. Fig. 1 represents the latter alternative. Assume a motor the construction of which is identical with that of an ordinary asynchronous motor and in which the number of phases of the rotor corresponds to that of the stator. Assume further that the starting motor, which in this case may be a direct-current motor, is connected to the rotor shaft. The bars operating on a three-phase current may be connected through three-pole switches with the stator and with the rings of the rotor to which the terminals of the phases lead. First the stator switch is closed and then the rotor is given by means of the auxiliary motor a speed double that of synchronism. At that instant the electromotive forces induced in the rotor have the same frequency as the main current in the stator, and they can be synchronized by closing the switch connecting the bars with the rotor rings. The series arrangement is diagrammatically shown in Fig. 2. The bars at the exit of the stator are connected by a three-pole switch to a reactance. The electromotive force at the terminals of the reactance must be higher than the electromotive force induced in the rotor at bisynchronous speed. At the instant the bisynchronous speed is attained, synchronizing may be established by closing the switch connecting the terminals at the exit from the stator to the rotor rings.

As compared with the ordinary synchronous motor the bisynchronous motor has the advantage of double speed and elimination of excitation by d.c. current. On the other hand, the bisynchronous motor suffers from the disadvantage inherent in all synchronous motors, namely, that it cannot start under its own power. One of the advantages of the bisynchronous motor is that it can be used either as an ordinary asynchronous motor, as a synchronized asynchronous motor, or as a bisynchronous motor, without having to make any important changes in its construction. The field of application of the new motor is in driving machinery which has to be operated at very high speeds. (*La Pratique des Industries Mécaniques*, vol. 9, no. 7, Oct., 1926, p. 300, 2 figs., *d*)

The Metropolitan-Vickers Phase Advancer

THE subject of power-factor improvement is assuming increase importance because of the spread of practice of supplying electricity at rates varying according to the power factor of installations. This makes it necessary at times to provide apparatus for power-factor correction, and the phase advancer here described belongs to this class. In principle the Metropolitan-Vickers phase advancer is a simple alternating-current exciter similar to the direct-current exciter which is connected in the rotor circuit of a synchronous induction motor, but differs from it in that it has a series-connected instead of a shunt-field winding. The series-field arrangement gives the phase advancer a self-regulating characteristic, so that the voltage generated by the exciter increases with increase of load on the main motor. The current circulating in the phase-advancer circuit is produced by the resultant of two voltages: the e.m.f. produced by the conductors on the rotor of the main motor slipping back through the rotating field, and the e.m.f. generated in the armature of the phase advancer. The arrangement of the circuit is such that these two e.m.f.'s assist one another. If the load on the main motor increases the slip becomes greater, the e.m.f. due to slip increases and thus also the resultant e.m.f. in the circuit is increased. This causes a corresponding increase in the current circulating and this, because of the fact that the phase advancer is wound with a series field, results in an increase in the voltage generated by this machine. These two voltages rise until the current circulates with sufficient power component to produce the required torque in the main motor, the phase advancer being so designed that this current is automatically produced with the desired amount of phase compensation. The amount of power-factor compensation is varied by rocking the phase-advancer brush gear. The position of the brushes for which any phase advancer has been designed is marked clearly on the machine as are also the limits between which the brush gear may be moved to vary the amount of compensation. Cable connections consist simply of three leads from the phase-advancer brushes to the main-motor slip rings. (*Mechanical World*, vol. 80, no. 2074, Oct. 1, 1926, p. 259, 3 figs., *d*)

ENGINEERING MATERIALS

Beryllium

BERYLLIUM or glucinium is one of the lightest metals known (specific gravity 1.84). Previous work, in particular by M. P. Lefeau, has indicated that it might become a valuable alloying element. Hitherto there has been no practical way to recover it from its ores, although one was announced in Germany some years ago, but the author now gives particulars regarding a method in which a double fluoride of beryllium and sodium is used with additions of a heavy alkaline-earth fluoride, such as barium fluoride. A rotating cathode is used (water-cooled steel tube). The metal deposit is often smooth and regular in form for many inches, but is more usually of a somewhat rugged and irregular outline. It has been found a simple matter to clean this metal in fused caustic soda. This leaves the surface quite brilliant and no loss of beryllium occurs unless the temperature has been too high, when the metal will be found to show a pickled instead of a bright surface.

The cathode metal appears to be of a very high purity and contains as impurities only very minute amounts of iron and carbon.

The purest metal yet obtained is non-ductile and not easily machined, but this may be found to be due to removable impurity and to incorrect heat treatment. (A. C. Vivian, National Physical Laboratory, Teddington, in *Transactions of the Faraday Society*, vol. 22, no. 5, no. 68, Sept., 1926, pp. 211–225, 15 figs., *eA*)

Pollopas, A New Glasslike Substance

DURING the past year mention was made several times in the technical and general press of a new "glass" which was said to be flexible, unbreakable, and endowed with several other valuable properties. Information is now available giving an idea of the character of this material. The new material, called "pollopas," appears to have been invented by two Austrians, Dr. Fritz Pollak and Dr. Ripper. It is made from kabamid (carbamid?) and formaldehyde and would therefore seem to belong to the family of condensation products. Once formed it is no longer soluble in water. Pollopas can be now produced as a perfectly transparent material in sheets of any size. It has a hardness of three on the Moh mineralogical scale and can be machined, drilled, ground, etched, and colored. It is therefore softer than glass and can withstand temperatures up to 280 deg. cent. (536 deg. fahr.), but carbonizes at higher temperatures. It is not affected by solvents, even dilute acids and alkalis. Its specific weight is about half that of window glass, from which latter it differs also in that it passes light without absorbing a large share of ultra-violet rays. This makes it suitable for use in hospitals, greenhouses, etc.

Pollopas appears to be a highly elastic material and does not shatter under a blow like glass. This makes it suitable for automobile windshields, goggles, etc. The low temperature at which it is formed permits a far greater freedom of coloring it than ordinary glass. The latter is formed at such a high temperature that only very few coloring materials can be used in its manufacture.

In addition to the manufacture of sheet, the same process with certain modifications permits producing a glue which is said to be suitable for use on glass, wood, and metal. With a still further modification it may be used as a varnish, and as such can be applied to soft cotton fabrics, as well as to straw and similar material. It is even claimed that a special solution of Pollopas has been successfully used as a binder for print colors in the textile and paper industry, and that because of the inherent freedom from coloration of the solution of Pollopas itself, very beautiful effects have been obtained. (P. Centner, *Association des Ingénieurs Electriciens sortis de l'Institut Electrotechnique de Montefiore*, vol. 4, no. 1, Jan., 1926, pp. 4–19, 13 figs. Also in *Dinglers Polytechnisches Journal*, vol. 341, no. 15, Mid-August, 1926, pp. 168–169, *gA*)

FUELS AND FIRING

Application of X-Rays to the Laboratory Jig Testing of Coal

THE paper under consideration describes a laboratory jig for the radioscopic inspection of coal. With this device the course of the jigging process can be kept continuously under observation by placing behind the jig a source of X-rays and in front of it a

fluorescent screen, on which the shadows of the gradually descending heavy particles may be viewed.

If an X-ray photographic film is substituted for the fluorescent screen, a radiograph of the separated contents of the jig is obtained. The author describes how the percentage proportions of clean coal and dirt may be obtained. It is not claimed that the results possess the accuracy given by fractional flotation, but merely that at the present stage of development they provide a rapid practical check on actual samples and afford a ready means of detecting and thereby controlling variations which might otherwise pass unobserved at the time.

Results tend to show that by the employment of X-rays in conjunction with suitably designed experimental jigs of larger dimensions, valuable data would be obtained regarding the separation, and, in some directions at least, without the necessity of having recourse to chemical analysis. The experimental work so far attempted has been on a scale which is admittedly inadequate either for maximum accuracy or for the thorough investigation of all the related problems which have already suggested themselves.

In the present author's opinion, X-rays should be applied to the examination of coal primarily as an instrument of research, although there are even now directions in which suitable equipment can be of real value for purposes of technical control, especially in large organizations where all the more usual scientific methods are constantly employed as a matter of course. In such cases the factor of cost is relatively insignificant. (C. Norman Kemp in a paper before the South Wales Institute of Engineers; abstracted through *Iron and Coal Trades Review*, vol. 113, no. 3056, Sept. 24, 1926, pp. 449–450, 3 figs., *pg*)

A New Pulverized-Fuel-Firing System

DESCRIPTION of a system developed by Clarke, Chapman & Co., Ltd., Victoria Works, Gateshead-on-Tyne, England. An interesting fact in the development of this system is that all the experiments were conducted on a commercial scale and not in a model plant in a laboratory. The first plant built had a boiler with a steaming capacity of 40,000 to 50,000 lb. per hr. at a pressure of 250 lb. per sq. in. and a total temperature of 600 deg. fahr.

The pulverizer is contained in a cylindrical case provided with a renewable lining in which rotates a single disk carrying a number of beaters in a manner resembling paddle wheels. The beaters are of manganese steel and are renewable. They are ground within fine limits of weight to obtain a good running balance. The life of the beaters is estimated at 1000 hr., and more than this with a soft material. The disk is driven at 1450 r.p.m. by a 50-hp. motor (Fig. 3).

In view of the heavy wear and tear to which this type of apparatus is subjected, the need for accessibility has been kept prominently in view. It will be seen from Fig. 3 that the beater disk is exposed merely by breaking the air-duct joint, loosening the cover nuts, and swinging open the cover. It is said that the disk can be removed and replaced within 15 min.

A point of importance is that the pulverizer is said not to be damaged by tramp iron, any pieces which can pass through the feed opening being rejected without injury to the apparatus. A magnetic separator is claimed to be unnecessary, and is not provided.

Surmounting the pulverizer is a separating chamber containing a system of baffles. The fineness of the product can be regulated at will, the coarse particles being thrown back by a deflector plate into the pulverizer. The fuel is ground sufficiently for 80 per cent to pass through a 180-mesh screen.

Mounted on a common shaft between the pulverizer and the motor is a fan for supplying primary air. The air supply is drawn from an air heater in the floor of the combustion chamber. For fuel containing 15 per cent moisture a temperature of at least 500 deg. fahr. is necessary, and a temperature of 600 deg. fahr. to 700 deg. fahr. is advisable. The fan draws the ground fuel from the separator and delivers it to the burners in the roof of the combustion chamber. The primary air derived from this fan constitutes about 25 to 30 per cent of the total air for combustion. The total power consumption of the pulverizer and fan unit is stated to be about 18 hp. per ton of moist coal.

With regard to fuels, it is said that fuels containing 15 per cent moisture have been employed for considerable periods without the need for any separate drying apparatus. The plant is advocated for the burning of low-grade fuels, fuels containing up to 30 per cent ash having been consumed with, it is understood, successful results. It has also been found possible to burn the semi-coke which is the product of low-temperature carbonization processes.

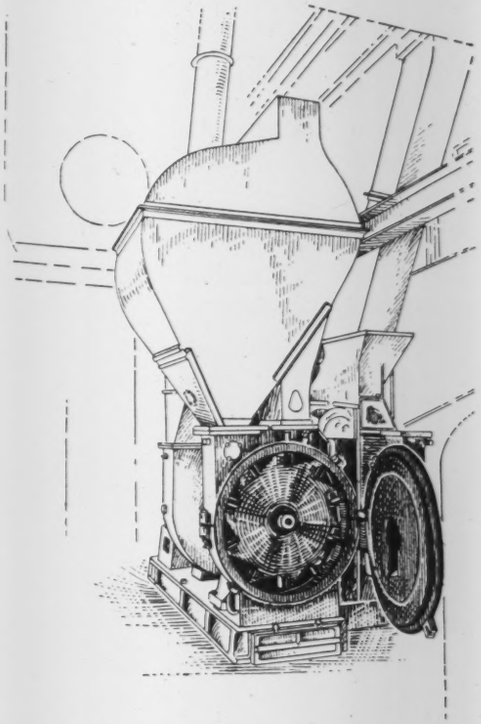

FIG. 3 CLARKE, CHAPMAN & CO. PULVERIZER WITH CASE OPEN

The overall cost of pulverizing and firing, including maintenance, is estimated at 2s. 6d. (60 cents) per ton. (*Mechanical World*, vol. 80, no. 2075, Oct. 8, 1926, pp. 279–280, 3 figs., *d*)

The Salermo Process of Low-Temperature Carbonization

THE Salermo process employs a retort which belongs to the class of externally heated retorts with continuous feed, the material heated undergoing continuous and regular stirring. An integral part of the process is the predrying by means of waste heat of the material to be carbonized.

The retort consists of semi-cylindrical troughs of mild steel, which may be of different sizes. Several troughs may be placed side by side under a common roof. Along and above each trough is a central shaft provided with stirring paddles fixed normally to the shaft. These paddles are placed close to each other but in different planes and may be made to revolve at any rate required. The purpose of the paddles is to cause the material in the troughs to move along from trough to trough and to keep it in constant motion "so that it behaves like an emulsion or a liquid."

As regards predrying, the material reduced to a suitable size is fed from a hopper on to a drying conveyor to a thickness of about an inch. It is then fed continuously down to a sill into the first trough of the series, the sill consisting of an arrangement of partition plates with the coal itself acting as the luting material. The preluting is done by the hot combustion gases while the retort is heated by means of hot gases from some outside source or by burning the gas evolved in the process, and finally by any other fuel, such as poor-quality coal. It is claimed that the plant is complete in construction, very compact, and requires but little brickwork. It is also very flexible as it is possible to vary the rate of charging of drying, of heating, and of carbonizing.

The following are average and conservative yields, based on tests carried out on a number of Scotch and Yorkshire coals:

Primary tar:	20-22 gal. per ton at 16,250 B.t.u. per lb.
Gas:	3500-4000 cu. ft. at 870 B.t.u. gross and 785 B.t.u. net per cu. ft.
Semi-coke:	75 per cent of the weight of the coal.

Equally satisfactory yields have been obtained from the treatment of lignites and oil shales.

From shales is derived a primary tar generally free from acid constituents, from which may be obtained motor fuel and also lubricating oils.

The process has been working for nearly a year at the Sarre mines, where two units deal daily with 25 tons of coal which is very wet and of low density. A further installation to deal with 200–250 tons per day has been ordered, and other plants are under construction. (*The Chemical Age*, vol. 15, no. 380, Oct. 9, 1926, pp. 346–347, 2 figs., *d*)

Future Trends

Automotive Fuels. From the estimated number of automobile engines the Committee of Eleven of the American Petroleum Institute has calculated the maximum fuel demand for 1930 at 13,249,000,000 gal. From a comparison of these demands with the estimated available supplies it would appear that if the gasoline type of liquid fuel is to continue as the principal source of automobile power, petroleum supplies will be inadequate and the chemist will have to solve the problem of cheaper and efficient production of fuel from some other source. The hope lies in improvements in the production of crude oil and the generation of motor fuel therefrom, the new cracking process not only permitting cracking any type of crude oil but also providing a motor fuel with anti-knock properties due to the high degree of unsaturation of the cracked product. It is now recognized that olefins have no gumming effect and are desirable constituents because of their anti-knock effect. Color and specific gravity as criteria for quality of gasoline are now superseded by anti-knock value and volatility. Recognition of the value of the unsaturated constituents of gasoline has radically changed the methods of refining the cracked product so as to avoid polymerizing and removing the olefins.

As anti-knock fuels become more generally available, manufacturers of motor cars are expected to increase combustion ratios from year to year to a figure probably not exceeding six to one. The probable trend in automobile fuels when the petroleum supply becomes inadequate is difficult to predict, and among sources of petroleum substitutes are mentioned alcohol from fermentation, gasoline from oil shale, motor fuel from coal, etc. (A. C. Fieldner and R. L. Brown, Pittsburgh Experiment Station, Bureau of Mines, Pittsburgh, Pa.)

Low-Temperature Carbonization. Conditions and necessities in this country in so far as they affect the development of low-temperature carbonization are radically different from those which prevail in Europe. For example, Americans are not so much concerned with the volume of the liquid products as they are with their value. In this country also the limitations in the cost of processing are more pronounced by reason of the competition a product must meet in the almost unlimited amount of cheap fuel available without processing.

The development of low-temperature carbonization with us, therefore, in order to meet such competition must proceed along lines involving conditions of large-volume production with minimum cost of labor, fixed charges for investment, and depreciation and upkeep expense, and high-value factors in the various products which will meet in the highest degree these adverse charges against the process employed. The early argument of lower cost as an accompaniment of lower temperatures used in carbonization has been more than offset by the elaboration of mechanical features, which because of manufacturing and maintenance cost, deterioration, and fixed charges have more than counterbalanced the possible advantage of heat conservation.

One other feature of the case should be mentioned, namely, the available market. Manifestly a product which competes with anthracite at from $15 to $20 per ton has a greater leeway in the matter of expense of production than a product which must compete with cheaper fuels selling on the market for less than $10 per ton.

There are at the present time some four processes in this country which are in or just entering the commercial stage and whose fundamental principles or environment meet the conditions thus outlined to an extent that would seem to forecast successful operation. It is sincerely to be hoped that this will be the outcome, not only because of the improved type of fuel thus to be made available, but also because the successful carbonization of the widely divergent and extensive quantities of coal thus processed is an exceedingly important step in the ultimate production of the ideal fuel—gas.

It is of interest to note a few typical examples of those processes which are now in or just entering the status of commercial production, making use of that fact as evidence that they have at least passed through the stage of preliminary experimentation.

The Smith Carbo-coal process, as modified by C. V. McIntire, engineer in charge, is a three-stage process: first, low-temperature carbonization at 460 deg. cent.; second, briquetting; and third, a final carbonization. It is operating within range of a market accustomed to an anthracite standard of cost. The final product for domestic use approaches the ideal, and has reached a stage where operations have been substantially continuous for six months.

The McEwen-Runge process, now being installed as an adjunct to one of the large power plants of the country using pulverized coal, operates in a manner to remove the volatile matter by allowing the pulverized coal to drop through a heated vertical tower about 6 ft. in diameter by 30 ft. in height. The minute granules of low-temperature coke are in suitable condition for burning directly as pulverized fuel in the power plant or for briquetting and carbonizing for the production of a domestic fuel. A production of 210 tons per unit per day is possible.

The Green-Laucks plant of the Old Ben Coal Corporation, Chicago, which has been operating on a 24-ton-per-day schedule, is being rebuilt for large-scale production. This method employs a spiral movement upward between heated walls approximately 5 in. apart and heated to about 600 deg. cent. The process is continuous and delivers solid, irregular lumps averaging about 2 to 3 in. in diameter. This is an ideal domestic fuel, smokeless in combustion and with every desirable quality, since it lends itself to use in ordinary household appliances, including the open grate.

The Knowles Sole-flue oven has made upward of 100 tons of low-temperature coke and is preparing to enter upon regular industrial production. In the process the floor only of the oven is heated. The layer of coal—8 or 10 in. deep—receives a considerable amount of heat not only from the floor but also from the hot gases ascending through the mass. The arch above the floor is not heated; hence the gas after leaving the coal is not subject to secondary decomposition. Both the oven and its operation have the advantage of simplicity, and the product is of an exceptionally high grade. Indeed, there is a well-founded rumor that one of our large industrial centers stands ready, provided this fuel can be produced at a cost equivalent to other fuels in their market, to require by municipal ordinance that no raw coal be burned in that municipality. (S. W. Parr, Univ. of Illinois, Urbana, Ill.)

Cotton Textile Industry and Cellulose Chemistry. The cotton textile industry is one of the largest cellulose-using industries. Although of all the cellulose industries this one is more largely dependent upon mechanical operations, it nevertheless deals with a complex chemical material, and a wider recognition of this fact in the industry might well result in notable advances. This is the more true since rayon has been finding its way into cotton textiles in increasing amounts.

For example, every cotton man knows how the strength of cotton varies with the moisture content, yet the reason for this is not fully understood. It would be very helpful to have a thorough knowledge of the relationship between the physical properties of cotton and the character of the soil on which it was raised. Such a study might lead to ways of controlling certain desirable properties, and possibly even of varying them at will, and might perhaps also throw light on the perplexing problem of "neps." The work might well be extended to include a study of the effect of chemical properties on the various physical characteristics on which depends the successful use of cotton fiber in the various textile operations. It is recognized that certain natural impurities in fibers seem to have an effect on these properties, and the study of these impurities and their effects might well yield valuable results.

Mercerization is an example of what the treatment of cotton as a chemical material has done for the textile industry, and it is not inconceivable that further application of this same point of view might produce even more valuable results. Perhaps the one development which would bring the textile chemist to realize this more quickly than any other would be the appearance of an inex-

pensive, strong synthetic fiber, and this is by no means beyond the range of possibility. (Gustavus J. Esselen, Jr., Skinner, Shirmer & Esselen, Inc., Boston, Mass.) (Future Trends in Industrial and Engineering Chemistry. Symposium of papers of general interest to mechanical engineers presented before the Division of Industrial and Engineering Chemistry, at the meeting of the American Chemical Society, Philadelphia, Pa., Sept. 6–11, 1926; abstracted through *Industrial and Engineering Chemistry*, vol. 18, no. 10, Oct., 1926, pp. 1009–1040, *g*)

X-Ray Studies of Coal and Coke

H. COURIOT in 1898 published the first important work on radioscopic analysis of coal and coke. This type of analysis is based upon the variation of absorbing power with composition. Coal is essentially a mixture of combustible organic constituents made up of finely divided free carbon, hydrocarbons, and substitution complexes plus non-combustible mineral matter such as calcite or pyrites. Carbon, hydrogen, and oxygen are all very transparent to X-rays. Sulphur and calcium are much less transparent, and iron is relatively opaque to the wave lengths used. Hence in a radiograph of a lump of coal the light areas indicate relatively pure carbonaceous material, darker areas indicate the presence of some sulphur, calcium, iron, or other elements of higher atomic weight than carbon, and the very black portions are dominantly of high atomic weight.

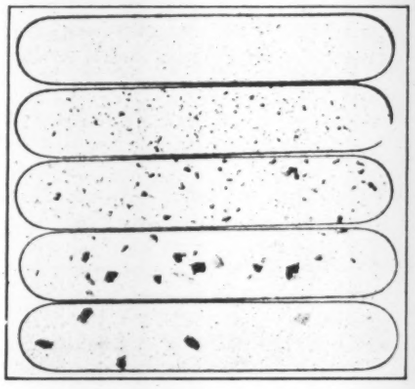

FIG. 4 RADIOGRAPH OF GRADED SAMPLES OF COAL, SHOWING DISTRIBUTION OF NON-COMBUSTIBLE MATERIAL

During the preparation of the coal for market further information as to the distribution of the non-combustible material in the different sizes can be obtained from pictures of graded samples (Fig. 4), and, similarly, the distribution of ash in coke is disclosed.

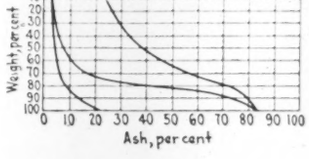

FIG. 5 ASH-CHARACTERISTIC CURVES FOR HIGH-ASH COAL BEFORE WASHING

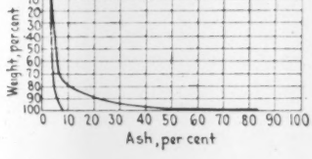

FIG. 6 ASH-CHARACTERISTIC CURVES FOR HIGH-ASH COAL, WASHED

The method is particularly valuable in the analysis and control of coal-washing processes. Kemp and McLaren have directed special attention to this and have developed the technique and equipment to a high degree of efficiency. The method consists essentially in using a narrow jig with parallel faces of a material fairly transparent to X-rays. This is placed transversely in the X-ray beam, filled with the sample to be tested, jigged, and examined with a fluorescent screen or recorded on a photographic film. As the cell is of uniform thickness the picture will be slightly and uniformly mottled if the contents are clean, pure coal, but will show darker spots where ash is present.

A detailed description of the method of preparing and interpreting the Henry or ash-characteristic curves is outside the scope of this paper. It is treated at length in the paper by McLaren. Briefly, the sample is jigged in a suitable hand jig until "effectively arranged in an ideal washing bed." Layers of this bed are removed successively, dried, weighed, and incinerated. The percentage of ash in each layer is then plotted against the percentage weight of the layers, reckoned downward. In Fig. 5 the middle curve represents the actual ash content of the corresponding layers. The left-hand curve is derived from this by dividing the total area under the ash curve down to a certain level by the weight of material down to that level. It thus represents the average ash content of the portion of the sample above the level in question. The right-hand curve is obtained similarly by dividing the area above the ash curve by the weight of material below the level. It consequently represents the average ash content of the lower portion of the sample. The lower end of this curve coincides with the end of the ash curve and represents the removable ash. The upper end of this curve and the lower end of the left-hand curve both represent the average ash content of the whole sample. The radiographic record of this bed is shown on the extreme left for the sake of comparison. The coördination between the top of the ash zone in the radiograph and the horizontal portion of the curve is notable. Fig. 6 depicts the corresponding curves and radiograph for the coal after washing.

X-rays can do more than disclose the distribution of materials in this way. They permit determining also the diffraction pattern of coal, showing its structure and enclosures. The methods of obtaining diffraction patterns have been referred to in another connection (Leon Cammen, Crystalline Structure of Metals—Pt. II of Principles of Metallurgy of Ferrous Metals for Mechanical Engineers, in MECHANICAL ENGINEERING, vol. 47, no. 6, June, 1925, p. 479).

Among the practical applications of diffraction analysis may be mentioned: (1) Determination of the state of combination of the elements comprising the ash; (2) determination of the relative proportions of the various ash constituents; (3) study of the modifications in the ash composition during combustion in the furnace; (4) fundamental study of the carbonization characteristics of coal. (Paper by Ancel St. John, consulting engineer, New York, N. Y., before the Pittsburgh Meeting, Oct., 1926, of the *American Institute of Mining and Metallurgical Engineers*, no. 1587-F. Abstracted from preliminary print, 13 pp., 14 figs., *ge*)

HEATING AND VENTILATION (See Refrigeration: Air Cooling in an Office Building)

INTERNAL-COMBUSTION ENGINEERING (See also Aeronautical Engineering: The Gas-Starter System for Aircraft Engines)

Diesel Engines Burning Producer Tar

A GERMAN concern, the L. Schwartzkopff Machine Co., of Berlin, has succeeded in running a Diesel engine on lignite tar as fuel. This tar is derived from the heating gas used for annealing purposes. The producers equipped with exchangeable retorts utilize industrial briquets. Part of the gas is taken from the retorts by suction and freed from the tar. This tar has the following properties: Black green color; melting point, 40 to 50 deg. cent. (104 to 122 deg. fahr.); coking residue, approximately 2 per cent; minimum heating value, 9100 to 9400 kg-cal. per kg. (16,380 to 16,920 B.t.u. per lb.).

The Diesel engine used is of the air-injection type and has an output of 440 b.hp. As long as the tar can be supplied to the cylinders in the liquid state the engine operates without ignition oil. All piping up to the fuel pump is therefore heated by the cooling water of the engine. Before starting, the tar in the tanks and piping is solid, and a second fuel is therefore required for starting and warming up the engine. While this is being done a small starting reservoir of tar is also warmed up to the melting point by a hot-water circulation. The same fuel pump is used for the initial fuel and the tar.

The employment of one and the same fuel pump for two different fuels at first gave rise to minor difficulties, because the starting oil must be of such a nature that when mixed with tar no precipitate is formed. Investigations made with a number of oils at 80 deg. cent. showed that they all produced certain pitch-like precipitates when mixed with tar. With oils derived from lignite they were a minimum and softest, while with mineral gas oils they were considerable and hard throughout. So far two kinds of lignite oils have proved most satisfactory.

When large quantities of producer tar are available and for this reason gas oil is to be saved, the electric heating device heats the fuels quicker than the water does, which itself has first of all to be heated. Using the engine cooling water alone it generally takes

20 to 30 min. before the starting fuel can be turned off and the tar turned on. The engine then runs with tar only until shortly before being shut down; before stopping the engine the starting fuel is turned on for a short while. Small loads amounting to less than one-quarter full load cannot be run by the engine if not specially designed for tar fuel. The tar then remains in the fuel pump and fuel piping to the individual cylinders so long that it cools down too far.

The cooling caused by the injection air can also be injurious to the small quantity of fuel involved. However, by adding some constructional modifications it would be possible to maintain the service with tar even at very small loads. But, on the other hand, it is also a simple matter to turn on a cock to the starting fuel when running on small loads.

The higher ash content of tar compared with that of Diesel oils did not give rise to any difficulties. Parts of the fuel pump, which are readily exchanged, evinced slightly increased wear. The atomizer parts also became more easily soiled owing to the deposits produced when mixing the tar with oil. The cylinders showed no symptoms differing from those obtaining when using Diesel oils. The fuel consumption during the reception tests was even more favorable when using tar than when gas oil was used.

The average fuel consumption during one year amounted to 350 grams per kw-hr. produced at the switchboard. Of this amount 260 grams were tar and 90 grams starting oil. The share of starting oil includes all trial runs and running against very small loads. For the normally loaded engine and working in one shift, this share figured out at only 14 per cent. In actual service it was proved that the engine worked 50 per cent cheaper with producer tar than with Diesel oil fuel. This increase in value is an incentive for the producer service to recover more tar from the coals and to more carefully supervise the plants so that gas piping keeps cleaner. The higher separation of tar results in a purer gas, which should serve as a superior substitute for the still-much-used coal gas. (M. Jaretzky in *Engineering Progress*, vol. 7, no. 9, Sept., 1926, pp. 241–242, 4 figs., *d*)

A New Double-Acting Werkspoor Diesel Engine

AMONG other things, novel cylinder heads have been introduced in the new six-cylinder double-acting engine type. The novelty lies in the employment of six small valves which serve both for the inlet and the exhaust of the burned gases. A double-function valve with a director valve has been employed before, e.g., as in the Beardmore-Tosi engine, but as developed by Werkspoor it differs in that a number of valves arranged around a circle work in connection with a circular director valve. This provides a symmetrical layout which is desirable from the point of view of heat stresses.

Interesting features of the operation of the engine are the abstance of vibration and silence of operation. The only noise of any importance observed by the author was that produced by the air inlet, and in order to reduce this to a minimum the intakes are provided with gratings of square section situated between the cylinders. At the back of the engine there are mounted on each cylinder pressure gages indicating the working of the pistons with regard to pressure sealing. The annular space between the upper and lower portions of the piston at each stroke communicates with an opening in the cylinder wall to which a gage is connected. When the piston rings leak on one or both sides, the pressure is communicated to the annular space and the gage will show it. The observer can see on the gage a small movement of the hand every time the piston passes, indicating that only a trifling pressure is being built up in the annular space. The compression on the under side of the piston is about 225 lb. per sq. in. and the maximum pressure does not exceed 425 lb. per sq. in. Based on an output of 4000-shaft hp. for a six-cylinder engine, the weight is about 290 lb. per b.hp.

It is contended by some engineers that the under portion of the Werkspoor double-acting engine should be regarded as working on the hot-bulb principle. This, however, in the author's opinion is not justified, for, the feature of constant pressure being absent, the system is far removed from that of a hot-bulb engine since there are no surfaces to initiate or assist combustion. (*The Motor Ship* (Great Britain), vol. 7, no. 79, Oct., 1926, pp. 240–241, 5 figs., *d*)

Solid-Fuel Internal-Combustion Engines

RECENT experiments made on internal-combustion engines using coal as fuel prompt a review of accomplishments made along these lines to date.

A. Schnürle uses an ordinary crankcase-scavenging two-cycle engine whose upper cylinder end is equipped with a retort containing incandescent coal. As indicated by the diagram, a porous diaphragm, *c*, consisting of zirconium oxide keeps the fuel out of the cylinder, but permits a relatively unobstructed flow of air and gas back and forth from the glowing mass of coal.

After the cylinder has been scavenged in the usual way, fresh air is compressed by the piston and forced through the screen into the coal bed. There it promotes combustion; after having been partially transformed into hot gas and absorbed heat, the gas mixture, which is now no longer burning, goes back into the cylinder during the expansion stroke. Owing to the heat which they have taken up, the mean effective pressure of the gases is greater during the expansion stroke than during compression, which of course accounts for the ability of the engine to deliver power. Its fuel consumption is stated to be 0.93 lb. of granulated coal per b.hp-hr.

Powdered-coal engines have recently been brought to a stage where they will run by maintaining high air and gas velocities in the cylinders at all times during the cycle. As the result of this,

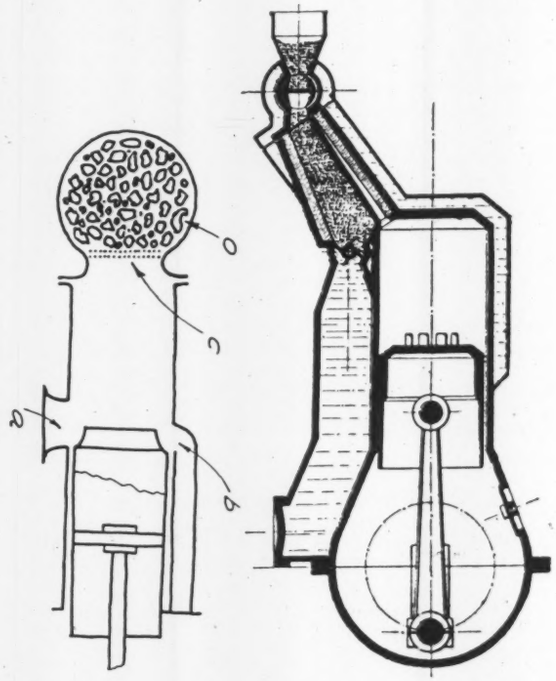

FIG. 7 DIAGRAMMATIC VIEW OF SOLID-FUEL INTERNAL-COMBUSTION ENGINE

deposition of solids is minimized and the choking up formerly found troublesome is avoided. Headway has also been made against lubrication difficulties arising out of the adhesion of coal dust to the lubricated engine parts. Although this has apparently not been completely prevented in the cylinders, the effects have been localized there by providing such devices as would be necessary for stopping all communication between the cylinder and crankcase. Such an engine is claimed to have run satisfactorily for 1000 hr. (*Oil Engine Power*, vol. 4, no. 10, October, 1926, p. 618, 1 fig., *d*)

The Pobjoy Aircraft Engine

IN CONNECTION with the description of the Cranwell light airplane 4, some information is given on the so-called "P" engine designed by Captain Pobjoy in England. It is a 7-cylinder radial air-cooled engine of unusually low power-weight ratio and of unconventional design. Captain Pobjoy was guided in its design by the principle that all parts subject to heavy loads of one sort or another should be very substantially built, while so far as possible there should be no parts which are not contributing to the work of the engine

and helping to pay their way. The result has been an engine differing in many respects from orthodox practice, but achieving a maximum output of 65 b.hp. for 100 lb. of weight, this figure including the weight of two magnetos. The fuel consumption is said to be just over 0.5 pint per hp-hr. The Cranwell airplane is also of interest because it was built by members of the Cranwell Light Aeroplane Club. (*Flight*, vol. 18, no. 35/923, Sept. 2, 1926, pp. 548–550, illustrated, *d*)

LUBRICATION

Michell-Bearing Lubrication and Experiments on Oil Films

THE following paragraphs are abstracted from a paper entitled, The Mechanical Parts of Large Winding Engines. Another interesting part of the same paper, which is not abstracted, owing to lack of space, is that dealing with gearing in large winding engines.

The ordinary bearings described, while suitable for use with gears of coarse or moderately coarse pitch, are not the best for use with fine-pitch gears, which require the maintenance of the utmost accuracy. It has been found advisable, therefore, to adopt a special design of bearing for use with the latter. This design is the result of extensive research on high-duty bearings, and involves special arrangement of the oil inlet duct, clearances, and bearing crowns. In such bearings it is of fundamental importance that an oil film be maintained between the shaft and the bearing surface, and the special features in the design insure the fulfilment of this condition, on principles similar to those employed in the Michell bearing, which enable the friction to be reduced to one-twentieth of the figure previously obtained. As an instance of the capacity of the oil film to withstand heavy loads without being squeezed out, it may be noted that a few years ago a common rule for fixing the proportions of bearings was to insure that the surface speed in feet per minute multiplied by the pressure of the projected area in pounds per square inch should not exceed a constant, say, 150,000. With pressure-lubricated bearings this constant may safely be made 600,000. During the research on bearings referred to above, it was determined that the breakdown of the oil film actually does not occur until the product of pressure and speed equals about 6,000,000, or, in other words, there is a factor of safety of about 10.

Interesting experiments have been made to determine the hydrodynamic pressure in the oil film at various points in a loaded bearing crown, and it was found that this pressure at the maximum point is about twice the static load, although with an imperfectly bedded step the pressure in the oil film may rise to five or six times the static load. (Percy R. Roberts and Alexander C. Anderson in The Mechanical Parts of Large Winding Engines, paper no. 4610 of the *Institution of Civil Engineers*, session 1926–1927, no. 1, October, 1926, pp. 18–21, *g*)

MACHINE PARTS AND DESIGN (See Pumps: "Roloid" Pump Gears)

MARINE ENGINEERING

The Cockburn High-Lift Safety Valve

IN THE power plant of the high-pressure turbine steamer *King George V* the valve illustrated in Fig. 8 is used. The ordinary type of safety valve with a small lift can easily become a trap for grit, etc. when the valve is blowing off. When the valve closes down on such grit, indentations are made in the seat, and with the escape of high-velocity steam, grooves are soon cut. Because of this a high-lift type of safety valve is used in the installation here described.

The outstanding feature of the improved high-lift safety valve which is illustrated is that it has double the discharge capacity of an ordinary safety valve having the same diameter, and consequently it is accepted by the Board of Trade and the classification societies at half the area given by their standard safety-valve formulas. The increased discharging capacity of the valve is obtained by utilizing the pressure of the waste steam—or "back pressure"—to act on a piston which is arranged at the bottom of the valve casing, and so to increase the lift of the safety valve proper. A further advantage of this type of valve is that the diameter of the waste steam pipe need only be half the area usually required. The valve chest with the connecting flange, the two valve-seat housings, and the central discharge passage behind the valve, is, like the casing and the casing cover with its easing shaft brackets, made of cast steel. Stainless steel is employed for the lids and spindles of the safety valves, which rest on a nickel-alloy seating. The piston above the valve proper is also made of nickel alloy. In each valve casing there is a nine-coil spring 10 in. in length which is compressed to about $9^3/_8$ in., and when set is fastened by a padlocked cotter passing through the top part of the spindle. From the drawing given it will be seen that the top of the valve spindle above the spring passes through a gun-metal guiding bush, which provides an additional safeguard against the spindle jamming. A relief hole is cast in the wall of the casing as shown. The easing shaft is provided with solid-forged fork pieces, which project under the cap and serve to lift the valve. As the safety valve described is mounted on the end of the superheater drum, a rod attached to a lever on the easing shaft is brought down to a convenient level above the stokehold floor, and is fitted with a handwheel and screw-operating arrangement. Each of the two 2-in. high-lift double-spring boiler safety valves is designed for a working pressure of 575 lb. per sq. in. and a test pressure of 1150 lb. Each valve is capable of dealing with a total evaporation of 20,000 lb. of steam per hr. at a total steam temperature of 750 deg. fahr. (The High-Pressure Turbine Steamer *King George V*, No. 3 of a serial article in *The Engineer*, vol. 142, no. 3689, Sept. 24, 1926, pp. 328–330, illustrated, *d*)

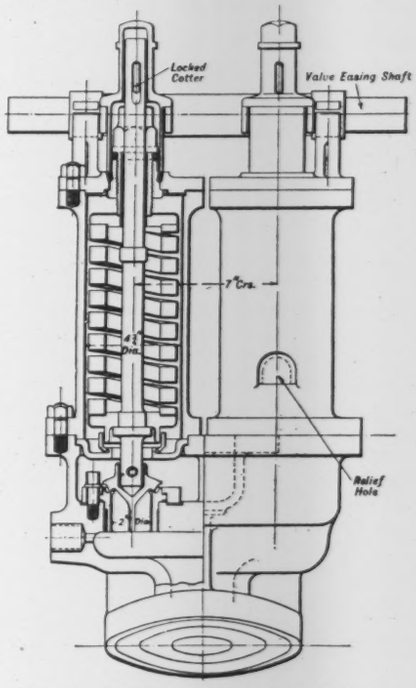

FIG. 8 COCKBURN HIGH-LIFT SAFETY VALVE USED ON HIGH-PRESSURE TURBINE STEAMER "KING GEORGE V"

POWER-PLANT ENGINEERING (See also Marine Engineering: The Cockburn High-Lift Safety Valve)

The Alden Turbine-Condenser Expansion Gasket

THE difficulty in making a satisfactory turbine-exhaust-nozzle joint has led to the development and testing of a simple type of hydraulic or pneumatic expansion gasket that requires no flange

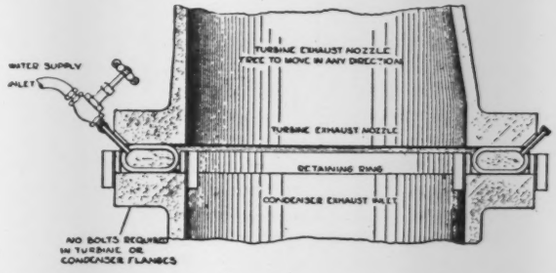

FIG. 9 SECTIONAL VIEW OF EXPANSION GASKET INSTALLED

bolting and is made of high-temperature rubber steam hose or tubing to withstand temperatures that would prevail under atmospheric conditions. The tube is provided with two small openings for the introduction of water under pressure.

As shown in Fig. 9, the gasket is mounted between the faced and the unbolted flanged surfaces of the turbine exhaust nozzle

and the condenser-inlet nozzle. It will permit of expansion in any amount and in any direction to be met with in practice without subjecting either the turbine casing or the condenser shell to any induced stresses. The gasket is adaptable to a pipe section of any shape—circular, rectangular, or elliptical. Experience has shown that a tube $3^1/_2$ in. in diameter will probably meet all conditions, but upon occasion it can be made in larger or smaller sizes.

Shop tests made with a $3^1/_2$-in. gasket mounted between two flanges showed that the critical water pressure inside the gasket at which leakage started when the distance between flange faces was 3 in. is 12-lb. gage, for a distance of $2^1/_2$ in. it is 4-lb. gage, and for a distance of 2 in. it is $1^1/_2$-lb. gage. In making the characteristic tests the gasket pressure at which leakage began was determined by providing the gasket with an external water seal and noticing by the decrease in water level in this seal the gasket pressure at which leakage started. This gasket was developed by B. W. Dennis (Mem. A.S.M.E.), Columbus, Ohio. (*National Engineer*, vol. 30, no. 11, Nov., 1926, pp. 86–87, *d*)

A Long Steam-Line Delivery

SINCE May, 1925, a steam line nearly a mile in length has been in operation at East Walpole, Mass., carrying 30,000 lb. of steam an hour at 165 lb. for 24 hr. a day. The line was designed to transmit steam ultimately at a pressure of about 200 lb. with 100 deg. superheat for a distance of 4550 ft., but at present the initial pressure is about 165 lb. and there is no superheat. It carries the steam from the East Walpole plant of Bird & Son, Inc., to that company's Norwood plant. The line consists of 8-in. steel pipe of 0.322 in. thickness.

Because of the fact that this pipe line was constructed on the railroad right of way, it was necessary to keep the center line of the pipe at least 8 ft. from the center line of the railroad tracks, which left too little room to use expansion U-bends; it was necessary, therefore, to use slip joints in almost all cases. Crosshead-guided expansion joints were selected with bodies of cast steel and slip tube of steel, copper plated, having a maximum traverse of 8 in. They were located every 140 ft., or as near that as possible. The base of each joint was securely anchored in a solid reinforced-concrete pier, so that expansion of the line starts in each case at the anchored solid flange on the body of the joint and travels in the direction of flow into the next joint. At all changes of direction anchors were located ahead of—i.e., on the inlet end of—the turn, and expansion is in the direction of steam flow, which causes maximum travel of the pipe to occur on straight lines only and eliminates the necessity for alignment guides before the bend, the crowns of the bends being left free to move at right angles to the line.

All joints in the piping except at expansion joints and U-bends were butt-welded, V-type, electrically, and slightly reinforced by crowning over the weld. The welds were then air-hammered and annealed, the annealing being accomplished by the use of twin kerosene burners with an especially constructed portable furnace. The line is insulated with 85 per cent magnesia, two layers $1^1/_2$ in. thick, with joints staggered in alternate layers, a total of 3 in., and covered with two layers of Bird & Son's Paroid roofing.

In pipe lines of this length great care must be used in warming up, because of possibility of water hammer and unequal expansion strains. Attention must be given to gradual increase of temperature rather than pressure. To check the operation of warming up carefully, a recording thermometer with the bulb located approximately 200 ft. from the inlet valve is used, the dial being located at the inlet valve. About two hours are required to warm up the line when cold. Care is also exercised in shutting down, not because of water hammer but for the reason that sudden contraction puts undue strain on anchorages, alignment guides, and joints.

An externally controlled double-beat valve is used at the discharge end of the line, reducing the pressure from approximately 140-lb. gage to 110-lb.

Maintenance is limited to the repacking of slip joints about every two years, and in recognition of its stability the Hartford Steam Boiler Insurance Co. has accepted this line and insured it for $100,000.

The line was tested on Feb. 11, 1926. It was found that the actual heat loss is less than 3 per cent. The pressure drop is about 18 per cent. The original article contains a calculation showing how closely the performance of this line checks with the Ledoux formula, as given in the *Annales des Mines*. The error through the use of this formula was found to be only 0.6 of 1 per cent. Experience with this pipe would indicate that under certain conditions it is economical to concentrate the generation of steam at one point and distribute through steam lines to more distant points. The installation was designed by R. H. Baker Co., Cambridge, Mass., in coöperation with John A. Stevens (Mem. A.S.M.E.), of Lowell, Mass. (R. H. Baker in *Power Plant Engineering*, vol. 30, no. 20, Oct. 15, 1926, pp. 1095–1097, 5 figs., *d*)

Steam Pipes for Extra High Pressure and Temperature

ANOTHER paper on this subject was read by the same author over a year ago before the Institution of Engineers and Shipbuilders in Scotland and abstracted in MECHANICAL ENGINEERING, vol. 47, no. 5, May, 1925, p. 357.

By extra high pressure and temperature the authors means pressure from 400 lb. and superheat 750 deg. up. One of the greatest difficulties of this kind of piping is with expansion. Sliding expansion joints or ball joints have been fairly satisfactory with lower-pressure saturated steam, but are not satisfactory with superheated steam. Bends appear to be the only way to handle this question, and even ordinary bends do not work quite well. The problem has been largely solved by using corrugated tube. The corrugations in themselves strengthen the tube, especially as the process of manufacture thickens the wall of the tube; the corrugated pipe is then formed into a bend in the usual way and there can be no thinning of the wall in bending as all that happens is that the corrugations are somewhat opened out on the inside of the bend and closed up on the outside.

These corrugated pipes can be bent to a much smaller radius than plain pipe, and in extreme cases they can be bent to the same radius as an elbow; in all cases, to stand corrugating, the tubes must be of a good soft quality of steel and must be well made, free from variations of thickness; they are usually solid-drawn tubes, hot finish, 24 tons to 28 tons tensile, 25 per cent elongation in 8 in.

Bends made from corrugated tube are five times as flexible as similar bends made from plain tube, that is to say, if the same thrust is applied to both bends the corrugated one will move five times as far as the plain one.

A comparison of expansion bends of the lyre type is interesting. Such a bend made from plain tube and 138 in. high from the center of the main to the center of the pipe at the crown of the bend, allows for a movement of $2^1/_2$ in. out or in; a bend made from corrugated pipe of the same bore can be made 55 in. high and will give $2^1/_4$ in. out or in, and a similar bend 72 in. high $3^3/_8$ in. out or in, or 50 per cent more than the much larger plain bend.

For expansion purposes straight corrugated pipes are not often used for end-on movement between the flanges because the corrugations are not high and to obtain a very small end movement, 0.01 in. per corrugation, a pressure of many tons is required; but corrugated pipes, both bends and straights, are used with great success to overcome vibration or movements due to the working of a ship.

The severest test of their behavior under severe vibration has been on steam hammers, and an interesting case was that of a 50-ton steam hammer which, on account of the method of working, was subject to excessive vibration. When first started to work, steam was connected to it by a 5-in. plain steel bend, but the vibration was so great that the steam chest was broken off. A stronger chest was fitted and the steam connection made through a copper bend, but the life of these bends was so short, not more than a month, that replace bends had to be kept in stock, and the steam joints had to be remade on an average once a day.

A 5-in. corrugated bend 24 in. × 20 in. made from stock solid-drawn hot-finish tube $^7/_{32}$ in. thick was fitted and after working for two years, without remaking a joint, was taken out for examination. It was sectioned and the metal examined under the microscope, and the report stated that there was no sign of deterioration of the structure of the metal or of incipient cracks, and that there was no corrosion; the replace pipe put in is still working under the same condition.

A method of making a bend from plain pipe to a radius much smaller than that to which plain tube can be bent is by cutting pieces out of the pipe, bending it with the cuts on the inside of the bend until the sides of each cut meet, and then welding up the cuts. This is a method which should not be used with steam pipes for any great pressure, and certainly not with the pipes under consideration.

Injudicious anchoring causes expansion stresses by endeavoring to force the pipe into a position where it would not naturally go. The ideal plan is to have no anchoring at all, as it is frequently only necessary to guide the pipe in the direction in which expansion should take place; but this ideal cannot always be obtained, in which case anchors must be fitted, and considerable experience is required to place them in the right position.

As regards the method of attaching the flange to the pipe, the author recommends welding by means of the carbon-arc process, and claims that this method is fully as reliable as riveting and that the matter of the so-called human equation is not as fraught with danger as is generally supposed. Where branches have to be taken off pipes this should be done, in the author's opinion, by means of welded-on stools, and experience has shown that the acetylene process is the most suitable for this work. Branches welded on by the carbon-arc process do not seem to have stood up as well.

On the whole, the author believes that no drastic alterations are necessary either in material or in the method of manufacture to meet modern conditions in power-station or marine piping, but that great care and experience are necessary in all departments of the work, especially in design. (Paper by J. A. Aiton before the *Institute of Marine Engineers*, Sept. 14, 1925. Abstracted from preprint, *p*)

PUMPS

"Roloid" Pump Gears

THE design of teeth for a gear type of pump is not considered to have reached very high efficiencies. From this point of view the type described here and made by David Brown & Sons, Ltd.,

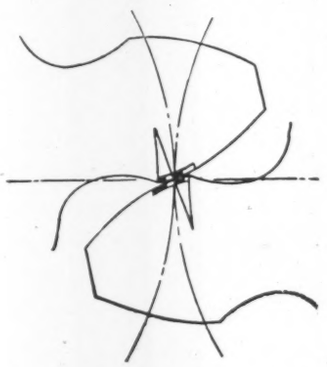

FIG. 10 EIGHT-TOOTHED INVOLUTE PINION PROFILES, SHOWING UNDERCUTTING

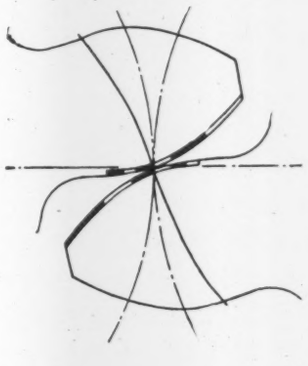

FIG. 11 EIGHT-TOOTHED "ROLOID" PINION PROFILES

Lockwood, Huddersfield, England, may be of interest. The profile of these gears differs from the ordinary involute tooth (Fig. 10) in that undercutting is eliminated (Fig. 11), while the number of teeth is reduced to the minimum. Pumps made with gears having only seven teeth are said to mesh correctly.

A further point in favor of the "Roloid" profile is that overlap of tooth contact is reduced to the minimum. This is contrary to normal practice in the design of gears for power transmission, but is of advantage in a pump as a trapping of liquid between the teeth is thereby avoided. The "Roloid" teeth are designed with considerable backlash. Tests are said to show that no loss in delivery results thereby if the tooth profiles are correctly designed. (*Mechanical World*, vol. 80, no. 2074, Oct. 1, 1926, p. 260, 3 figs., *d*)

RAILROAD ENGINEERING

Baldwin Three-Cylinder Locomotive

DESCRIPTION of three-cylinder engines of a new Mountain type built for the Denver & Rio Grande Western Railroad. These locomotives are to operate under unusually severe conditions, with the steepest grades 3 per cent and the sharpest curves 16 deg. The aim in designing the new locomotives was to obtain maximum capacity in a coal-burning engine of the 4–8–2 type without exceeding the specified weight and clearance limitations. Actually, the engines with the weight limit of 290,530 lb. on the driving wheels are capable of developing a tractive force of 75,000 lb., which is exceptional for an eight-coupled design.

Among the novel features of the engine is the arrangement of the three cylinder castings. The three cylinders are cast separately from each other, the middle cylinder being in one piece with the cylinder saddle and the two outside cylinders being made from the same pattern. The front frame rails are single with the outside cylinders securely bolted to them and to the central cylinder casting as well. The arrangement is such that the inside cylinder drives the second pair of coupled wheels, and the outside cylinders are connected to the third pair of driving wheels. All three cylinders take high-pressure steam. All are 25 in. in diameter with a stroke of 30 in.

The valve chamber for the inside cylinder is placed on the right side and receives its steam supply from a branch leading from the right steam pipe. The Walschaerts valve motion is used. The one on the left side is arranged in the usual manner, but on the right side the main crankpin has attached to it a double-return crank which operates two links, one for inside cylinder and the other for the right outside cylinder. The inside valve receives its lead from the corresponding crosshead and the movement is transmitted from the plane of the latter to that of the outside link through a horizontal shaft which has a fulcrum in a rocker having its bearing bolted to the main frames. This horizontal shaft passes through a crosshead to which the inside valve stem in attached. (*Railway Review*, vol. 79, no. 16, Oct. 16, 1926, pp. 565–568, illustrated, *d*)

A Storage-Battery Gas-Electric Switching Locomotive

THE largest storage-battery locomotive in the world, weighing 110 tons and capable of hauling a 1500-ton train equivalent to seventy empty or thirty loaded freight cars at a speed of 8 to 10 m.p.h. on a level track, has been built by the Chicago & Northwestern Railway Company. The control is so arranged that power can be taken entirely from the storage battery, or the gas-electric drive can be used. In storage service the battery can be used to supply power, while the gas-electric unit is used during slack periods to keep the battery charged. It is intended, however, to use the storage batteries as a source of power for the traction motors under ordinary circumstances; they can deliver 1000 hp. to the driving motors, and under ordinary conditions are capable of furnishing sufficient power to handle the locomotive for one day's service without recharging.

The auxiliary gas-engine generating set provided for recharging the batteries permits the locomotive to be kept in continuous service and operated if necessary on tracks remote from the regular charging facilities. The gasoline engine is a Winton 6-cylinder unit. To protect the cooling system against freezing when the engine is idle in winter, a small coal-fired motor is provided.

Within the past few years storage-battery locomotives have been developed until they are fast becoming a definite factor in modern transportation. Locomotives of a similar type but smaller have been in successful operation for several years in industrial plants.

The problem of electrifying the railroads in Chicago has been studied by most of the prominent electrical and railroad engineers of the country during the past decade. It is the opinion of many of these engineers that storage batteries can be used to advantage in propelling switching locomotives in many locations in Chicago. (*Railway Review*, vol. 79, no. 15, Oct. 9, 1926, pp. 541–542, 3 figs., *d*)

REFRIGERATION

Air Cooling in an Office Building

DESCRIPTION of the ventilation system of the American Radiator Company building in New York City, unique in that it was designed primarily for cooling the air in the summer time, although it can be used equally well for heating it in the winter months.

The fresh-air supply is taken from a convenient source on the

second floor and brought to the basement, then through the equipment room to the washers, where the entire cooling process for the air takes place. Four of these washers are provided, the first three wet and the last dry, to remove moisture in suspension in the air. The washers are divided into two sections, upper and lower, comprising galvanized-wire fronts and backs in which are placed smooth river stones of about first size. The cold water is sprayed over these through two distribution pipes in each washer and passes over the stones in a thin layer. The air also passes over these stones, coming in contact with a large surface of water and being affected by the cold surfaces of the stones. This process taking place in the first three washers cools the air nearly to the cold-water temperature, removes dust and suspended matter, and fully saturates the air. The cold water in this particular installation is brought in at 50 deg. fahr. and recirculated. The cooling of the water is taken care of by means of an automatically controlled CO_2 compressor of the Brunswick Kroeschell Co. with Baudelot coolers and water filters. The air now cooled to about 50 deg. fahr. passes over a dry cleaner and then over the reheating coils and through a mixing damper. The air can therefore be reheated to any desired temperature, the cold and warm air being mixed to form the air supply for distribution at any desired temperature and humidity.

The system was calculated to give the desired air change of about 300,000 cu. ft. per hr. for 95 deg. fahr. outside temperature with an inside temperature of about 80 deg. fahr. and a relative humidity of about 50 per cent, this being considered sufficient for extreme hot-weather conditions. In actual practice it was found that for very hot outside-weather conditions the inside-cooled rooms could not be kept more than about 10 deg. fahr. to 12 deg. fahr. below the outside temperature as the change for people entering and leaving the offices was otherwise too great. This degree of cooling, together with the constant supply of fresh air, dehumidified to a large extent, afforded very comfortable working conditions.

It was also found in practice that the long, partly uninsulated run from the sub-basement to the sixth floor, where distribution took place, was sufficient to reheat the cooled air without using reheating coils. This eliminated the necessity for carrying special steam on the boilers.

Whereas the distribution of warm air can be accomplished at fairly high velocities through relatively small outlets, cooled air reacts more quickly on the room occupants, because they are more sensitive to cold drafts. For this reason low velocity is essential. This requires a greater distribution or register-outlet area, and the plan of the ducts on the sixth floor, as laid out, clearly indicate these features.

The symmetrical planning of the ducts is apparent from a figure in the original article. The resistances of all ducts were carefully computed. When the system was first put in operation the distribution from the various outlets was so close that no adjustment of the friction dampers provided at the junctions was necessary. Clean-out openings are provided at regular intervals, so that the very essential annual cleaning can be taken care of without undue trouble.

When the system was about to be started many fears were expressed that it would be very difficult to operate and that the occupants would always want to keep the windows open. After a short explanation to all concerned and a few days' operation no trouble at all was encountered; in fact, when work had to be carried on after business hours, a special request was made to keep the system running as all agreed that it made working conditions much better.

If people had to leave the office for work outside or even for luncheon, they hurried back to their desks, enjoying the excellent air conditions in their offices. It was found that the working capacity on this floor was increased 25 to 30 per cent, leaving people fresh and untired after hours, whereas, for other floors and under similar conditions but without this cooling system, the occupants were quite exhausted and uncomfortable in hot weather. The installation was designed by Dr. Chas. Brabbée of Yonkers, N. Y. (W. E. Kugemann, Jr., Brabbée Laboratory, Yonkers, N. Y., in *Heating and Ventilating Magazine*, vol. 23, no. 10, Oct., 1926, pp. 67–72, 10 figs., *d*)

RESEARCH

Scientific and Industrial Research in Holland

The author, himself connected with a national research organization in England, calls special attention to the work of the Cryogenic Laboratory at Leyden, formerly under Kammerlingh Onnes and now under Keesom and De Haas. This laboratory is also working on phenomena occurring in strong magnetic fields.

The Research Laboratory of the Phillips Lamp Company at Eindhoven appears to be installed on a very large scale. While the purpose of the laboratory is clearly and frankly industrial—i.e., to improve the business of the Phillips Company—the method of achieving that result has been conceived in the broadest spirit, and the longest views are taken. As a result, extremely fruitful work has been done, and the laboratory itself has been considerably extended beyond what had originally been planned. On going round the laboratory, it is striking to find that only here and there does one encounter work in progress that deals directly with any specific problem of the company's manufacture—experiments on new "valves," on a new loud speaker, etc. On the contrary, room after room of this widespread building is devoted to research on purely fundamental problems. Thus there is a chemical division in the laboratory in which the separation of hafnium from zirconium is carried out on a considerable scale. These two, and others of the less-known metals, such as titanium, thorium, etc., are receiving particular attention, and it was interesting to see not only a stick of pure boron, hard enough to cut—not merely scratch—glass, but alongside of it rods of pure zirconium, which are so ductile that they can be readily rolled into strip and drawn into fine wire. A piece of the fine zirconium wire can be ignited with a match and burns with a greenish flame. Unlike burning magnesium, however, it does not give off a cloud of oxide; the zirconium oxide produced by the combustion retains the shape of the wire, and falls off under its own weight as its length increases. As the oxide of magnesium is not appreciably volatile, the difference in the behavior of burning magnesium must be due to the fact that magnesium metal itself is volatile, when a wire or ribbon is ignited, in the condition of vapor, thus leaving the oxide suspended in the air as a cloud of exceedingly fine particles.

In this laboratory the problem of producing zirconium, hafnium, and titanium free from oxygen and nitrogen is solved by effecting the reduction of the metal from a vapor (actually the vapor of the iodide is used) by contact with an incandescent tungsten filament in an otherwise highly evacuated glass vessel. The tungsten filament becomes covered with a deposit of the pure metal, and provided that a sufficient supply of the iodide vapor is available and that the temperature of the thickening filament is properly maintained by steadily increasing the heating current, rods of metal up to 4 or 5 mm. in thickness can be grown.

Another line of activity pursued in the laboratory is an interesting example of the way in which the investigation of seemingly abstruse physical problems may lead to important manufacturing improvements. The physical phenomenon investigated in this case was the dispersal or "sputtering" of metals which occurs when a rod or wire is made the cathode in a discharge tube in an atmosphere of an inert gas. It was found that a wire when treated in this way is steadily reduced in diameter, and that this reduction took place with great uniformity, since projections suffered most rapid dispersal. A valuable application to practice has been found in this discovery in the production of very fine wires—the process makes it possible to reduce wires to a diameter far smaller than can be obtained by any drawing process, while the surface of the resulting filament is practically smooth and uniform. (Dr. W. Rosenhain in *The Engineer*, vol. 142, no. 3689, Sept. 24, 1926, pp. 324–325, 4 figs., *d*)

SPECIAL MACHINERY

Automatic Sheet-Doubling Machines

An automatic doubler for sheet rolling was developed some time ago in the United States. The present articles describes another type of a similar machine constructed by the Friedrich-Wilhelm Hütte of Mülheim and covered by German patent No. 313,315. In it the doubling operation is automatic throughout, being di-

vided into the following separate operations: (1) Fixing the sheets in position on the floor level; (2) drawing the sheet into the floating channel; (3) pressing the two halves of the sheet at the float; and (4) lifting out the sheet and throwing it clear. The operation of the device is described in detail in the original article. The complete working operation takes from 8 to 10 sec., after which the machine is immediately ready to handle another sheet. The doubler can be operated by a youth or untrained worker. Several units of this kind are in operation in Germany and Japan and are said to be giving good satisfaction. (*Iron and Coal Trades Review*, vol. 113, no. 3058, Oct. 8, 1926, p. 537, 1 fig., *d*)

SPECIAL PROCESSES

The Ramar Process for Pulp Making

THIS process, invented by R. A. Marr, is controlled by the Union Bag and Paper Corporation. The principle of the process is as follows: Vegetable materials (hard or soft woods, grasses, bamboo, straw, etc.) are cooked under pressure in a dilute solution of neutral salts. This converts the intercellular material to a friable but insoluble condition; by a suitable mechanical treatment the binding material is disintegrated so that it can pass through the meshes of a wire-covered drum, such as those commonly used for washing pulp. The treatment which the inventor has found most satisfactory consists in first soaking the cooked material in water, and then passing it between rolls and through a shredder or through a pulper, and finally beating it in an ordinary beater.

If it is desired to remove the "intercellular cementitious material" a washing drum is used in the beater; but for many purposes this is not necessary, and if the binding material is left in the pulp, yields of 95 per cent and more in the oven-dry weight of the raw material can be obtained. Washing the pulp decreases the yield by about 10 per cent.

As the fibers are not cut up and broken, an exceptionally strong paper can be made. The process is also said to be cheaper as such common chemicals as sodium sulphate, magnesium sulphate, and even crude rock salt or sea salt are suitable for cooking; moreover the digesting liquors can be used repeatedly and no elaborate recovery plant is required as in present-day alkaline processes. Among the salts which can be used is iron sulphate. When tannin-bearing woods are cooked with this chemical a black pulp is obtained which is suitable as such for the manufacture of black papers, such as are used for wrapping sensitized photographic products. (*Canadian Chemistry and Metallurgy*, vol. 10, no. 10, Oct., 1926, pp. 231–232, *g*)

The Ford Wire Plant

ONE of the unique features of this installation is the enameling equipment, which is a battery of fifty machines made according to the design developed by Ford engineers. Formerly a good deal of trouble was encountered from spongy and porous enamel coatings. In the older designs of machines the wire passed from one side of the machine to the other, entering, say, at the right, passing to the top of the machine, thence down through the enamel for the second coat, again upward, this time nearer the center, and so on. Vertical electrically heated apparatus was used, with the greatest heat concentrated at the center. This caused the second and third coats to get a much more severe drying or baking, while the first coat was not quite dry, and the result was blistering and the production of porous coatings.

In the present machine the first two coats of enamel are applied and the wire passed through the hottest center part of the heating chambers, resulting in a thoroughly baked enamel. The third and fourth coats are baked in the outer portions of the heating chambers so that even if not entirely dry, blisters do not form. The Ford Motor Co. has found electricity far superior to gas for heating their enameling ovens. This is due to its greater cleanliness, lower fire hazard, and also to the cheapness of the current.

An interesting sidelight on the overall efficiency of the Ford plant is thrown by the fact that the man in active charge of this huge department was not a wire man before he started on this job, but picked up the information as he went along. Hardly any of the employees were trained wire makers, yet today the plant operates at top speed with great efficiency. A very noticeable thing about this plant—and this is true of the entire Ford factory—is the extreme care taken to keep everything as "clean as a whistle." There is no disorder, and every machine is arranged with the minimum of wasted floor space, and in strategic relation to the machine that does the next operation.

The plant is exceptionally well lighted by overhead light in the daytime, and powerful electric light at night. Despite the large number of enameling machines, the ventilation is so efficient that there is hardly a trace of an odor noticeable. Another feature is the excellent provision made to prevent accidents. Every machine that is not individually motor-driven (and most of them are) is lavishly provided with safety guards. (Carl Marx in *Wire and Wire Products*, vol. 1, no. 6, Oct., 1926, pp. 190–191 and 211, 2 figs., *d*)

TESTING AND MEASUREMENTS (See Fuels and Firing: X-Ray Studies of Coal and Coke: Application of X-Rays to the Laboratory Jig Testing of Coal)

TEXTILES (Cotton Textile Industry, Future Trends: See Fuels and Firing, Future Trends)

WELDING

X-Ray Investigation of Welded Joints

THE part played by welding processes in the multitude of fabricated structures made of metal is a very important one. This importance is being emphasized as more and more uses are being developed. Examples of such applications, where gas and electric methods have completely revolutionized well-known processes and made possible entirely new ones, are familiar to everyone.

As these methods and their application are developed the question arises as to the value of articles made in this way as compared with those made by other methods and as to just how far the welded joints may be depended upon. In order to answer such questions, it is necessary to subject the welds to tests which will indicate their fitness for the particular purpose. Many such tests have been devised.

The author briefly describes the radiographic method of studying welded joints, and comes to the following general conclusions: (1) The radiographic method will definitely show in the case of welded joints inclusions of gas, slag, oxide, or other impurities whose thickness in a direction parallel to the X-ray beam is more than 5 per cent of the total thickness of the sample. (2) This method of examination will show the presence of cracks or seams which are nearly parallel to the direction of the X-ray beam. (3) The method will indicate the failure of the welding materials to join completely the base-metal plates. (4) The method will not show cracks or layers which are normal to the X-ray beam. (5) The method will not tell anything about the crystalline condition of the metal.

As a result of these considerations, it seems that this method should be useful for the examination of welds in many cases. Because of its expense it cannot be at present applied to the routine inspection of an article, but in the development of new processes and of articles on which no expense should be spared which would tend to prevent failure, the method should prove valuable. No amount of inspection can take the place of careful and thorough workmen and nowhere is this more true than in the welding industry, but even when the workman has done his best under the most favorable conditions, there is the ever-present doubt which the penetrating eye of the X-ray beam will do much to set at rest. (John T. Norton, Assistant Professor of Physics, Massachusetts Institute of Technology, in *The Iron Age*, vol. 118, no. 7, Aug. 12, 1926, pp. 409–412; *Publications from the Mass. Inst. of Technology*, vol. 62, no. 44, Sept., 1926, 5 pp., 9 figs., *g*)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are:

ARCHIBALD BLACK,
Aeronautic Division

H. W. BROOKS,
Fuels Division

R. L. DAUGHERTY
Hydraulic Division

W. F. DIXON,
Machine-Shop Practice Division

CHARLES W. BEESE,
Management Division

G. E. HAGEMANN,
Materials Handling Division

J. L. WALSH,
National Defense Division

L. H. MORRISON,
Oil and Gas Power Division

W. R. ECKERT,
Petroleum Division

F. M. GIBSON and W. M. KEENAN
Power Division

WINFIELD S. HUSON,
Printing Machinery Division

M. B. RICHARDSON,
Railroad Division

JAMES W. COX, JR.
Textile Division

WM. BRAID WHITE,
Wood Industries Division

Aeronautics

Smoke-Producing Chemicals

A-4 What chemicals are used to produce the smoke in "sky writing" operations and in creating smoke screens?

This is supposed to be a secret process, but castor oil is one of the main constituents of the chemical used. (C. S. Jones, Curtiss Flying Service, Inc., Garden City, N. Y.)

Landing-Speed Reduction

A-5 What efforts are being made to decrease the landing speeds of airplanes?

Engineers are constantly striving for better design in wing curve to reduce landing speed. The application of brakes, while it does not reduce speed, does help to decrease the roll of the plane after it touches the ground. (C. S. Jones, Curtiss Flying Service, Inc., Garden City, N. Y.)

Forced-Landing Causes[1]

A-6 What are the causes of forced landings in airplane operation?

(*a*) About one-third of the total forced landings are due to engine trouble and about two-thirds to weather conditions, structural failure being extremely rare. The proportion of landings due to engine troubles is being steadily reduced year after year and should practically disappear some time in the future. Landings due to weather conditions also are being reduced through increased care in operation and attention to weather forecasts. (Archibald Black, Consulting Air Transport Engineer, Garden City, N. Y.)

(*b*) Records of our operations show that 30 or 40 per cent of our forced landings are caused by water failing in radiator, pipes, etc. This would seem to indicate that an efficient air-cooled motor should considerably decrease the number of forced landings. About 30 per cent of the forced landings are caused by accessory trouble, largely magneto, and the balance are equally divided between the failure of such parts as water pump, oil pump, cam-shaft drive, etc. (C. S. Jones, Curtiss Flying Service, Inc., Garden City, N. Y.)

[1] This subject has been discussed in a previous issue.

Fuels

Burning Lignite

F-4 By what methods has lignite been most successfully burned and what have been the test results?

Lignite has been successfully burned on forced-draft traveling grates, but far more successfully in pulverized form. Highly preheated air should improve all past performances with lignite. (T. A. Marsh, Western Engineer, Combustion Engineering Corporation, Chicago, Ill.)

Wood-Waste Firing

F-5 What methods of firing have produced best results in the firing of wood waste and what CO_2 values have been carried? What was the resultant furnace-wall maintenance and life?

Best results, to the writer's knowledge, have been obtained by burning wood refuse on hand-fired, Dutch-oven furnaces, feeding wood through the arch. Air should be admitted over the fuel bed. Preheated air is very desirable. (T. A. Marsh, Western Engineer, Combustion Engineering Corp., Chicago, Ill.)

CO_2 Values

F-6 What maximum CO_2 values have been found practicable in the operation of various types and sizes of coal-fired boiler furnaces with both stoker and powdered coal, and what has been the resultant furnace-wall and arch maintenance and life? What are ratios used of coal burned per cubic foot of furnace volume, also grate area per cubic foot of furnace volume, stating average analysis of coal used.

This is a question of tube area exposed to the furnace. Usually 13 per cent CO_2 is the maximum that the refractories will stand in water-cooled furnaces. With pulverized coal, 15 and 16 per cent CO_2 can be carried satisfactorily. With brick furnaces, 30,000 B.t.u. has been considered maximum, but with water-cooled furnaces, preheated air, and turbulence this may be appreciably increased. (T. A. Marsh, Western Engineer, Combustion Engineering Corp., Chicago, Ill.)

Oil and Gas Power

Splitting Oil-Engine Fuel Lines[1]

OG-2 In a power plant containing two oil engines of the solid-injection type, the fuel lines on one engine have split several times. The oil spray in this engine is very fine, while on the second unit the oil is sprayed into the cylinder in a coarse stream. Does the type of spray cause the breakage? If not, what is the cause?

Excessive fuel pressure is the most common cause of the splitting of fuel lines on solid-injection oil engines. The excessive pressure may arise from clogging of the spray nozzle or from the use of too small a spray orifice for the grade of fuel handled. The very fine spray in the engine which is splitting fuel lines indicates that the orifice is too small. (Edgar J. Kates, Consulting Engineer, New York, N. Y.)

Diesel vs. Gasoline Engine for Shovel

OG-3 Is one justified in installing a high-speed Diesel on a 1-cu. yd. shovel and discarding the present gasoline engine? This must, of course, include the item of engine life, as well as fuel savings.

There are several types of high-speed Diesels available for this work. The answer depends upon cost, fuel savings, and local conditions, and cannot be determined without knowledge of all the details. (J. W. A., New York, N. Y.)

In order for the writer to answer this question he would have to know the working hours of the shovel, the cost of the Diesel, the comparative costs of gasoline and heavy fuel oil, the average load on the engine, and whether or not the operator is a careful and intelligent person. It may be right to install a Diesel in one case and wrong in another. (R. Hildebrand, Chief Engineer, Diesel Division, Fulton Iron Works Co., St. Louis, Mo.)

Railroad

EQUIPMENT STANDARDIZATION[1]

R-2 Has there been any attempt to standardize railroad equipment?

Attempts to standardize railroad equipment date back to the '70's, and was one of the largest functions of the Master Car Builders' Association and the Master Mechanics' Association (merged during the Railroad Administration in 1919 into the American Railway Association, Division V—Mechanical). Hundreds of definite standards and recommended practices have been adopted, covering many details, such as wheels, axles, bearings, couplers, brake shoes, draft gears, rivets, bolts, nuts, lumber sizes, structural-steel shapes, air brakes, details of lighting systems, and other items. Recently the Association has adopted a standard design for the salient features of box cars, hopper cars, and gondola cars. It definitely standardized several types of passenger, freight, and shifting locomotives, and freight cars of various types, but these standards were not received with much favor, and there is very little attention being paid to them at the present time. (William Elmer, Special Engineer, Pennsylvania Railroad System, Philadelphia, Pa.)

MECHANICAL TRANSMISSION FOR DIESEL LOCOMOTIVES

R-3 Referring to Mr. Lipetz's paper, Part I of which was published in the August, 1926, issue of MECHANICAL ENGINEERING, have there been any Diesel locomotives of reasonably high tractive force built having a mechanical transmission?

(*a*) A Diesel locomotive equipped with an electromagnetically operated clutch system was recently completed by the Hohenzollern Locomotive Works, Düsseldorf, Germany, for Russia. This locomotive, the design of which is to be credited to Professor Lomonossoff, develops a tractive force of 42,000 lb. at 4 m.p.h. and a maximum speed of 34½ m.p.h. The weight in working order is 275,000 lb., distributed over five pairs of drivers, a four-wheel engine truck, and a two-wheel trailer truck. The main Diesel engine is of the six-cylinder, vertical, single-acting, four-cycle, air-injection, direct-reversible, M.A.N. submarine type and is made of cast steel. The engine develops 12,000 b hp. at 450 r.p.m., with cylinders of 17¾ in. diameter by 16 9/16 in. stroke. (M. B. Richardson, Associate Editor, *Railway Mechanical Engineer*, New York, N. Y.)

(*b*) No Diesel locomotives with reasonably high tractive power and having mechanical transmission have yet been built in the United States. (James Partington, Manager, Engineering Department, American Locomotive Co., New York, N. Y.)

(*c*) In the *Railway Age* for July 24, 1926, page 139, there is a description of a Diesel locomotive of 1000 horsepower equipped with mechanical transmission. Other experiments have been made in the past, and are being made at the present time. (William Elmer, Special Engineer, Pennsylvania Railroad System, Philadelphia, Pa.)

OPPORTUNITIES IN THE RAILROAD INDUSTRY

R-4 Compared with other industries, what opportunity has a mechanical engineer to progress in the railroad industry?

(*a*) It is the writer's belief that the opportunity of the mechanical engineer to progress in the railroad industry is as good as in any other industry, depending upon the initiative and energy of the engineer. He will go as far and receive as good pay as in other industries. (William Elmer, Special Engineer, Pennsylvania Railroad System, Philadelphia, Pa.)

(*b*) Commercial industry offers greater opportunity for advancement to the mechanical engineer than does the railroad, the chief reason being that commercial industry is permitted to earn a greater return on the capital invested and can afford to make a more attractive offer to the engineer. (Robert S. McConnell, Chief Engineer, Baldwin Locomotive Works, Philadelphia, Pa.)

[1] This subject has been discussed in a previous issue.

Textile

CONVEYING AND HOISTING SYSTEMS[2]

T-2 To what extent are conveying and hoisting systems used in textile mills?

(*a*) Conveying and hoisting systems in textile mills are of two types. The first is used for conveying and piling bales of cotton or bags of wool in the stock room or in the picking and opening department. These must handle bales weighing 500 lb. or more and are the ordinary heavy hoisting and conveying systems generally installed in machine shops. The second type is used for taking the warp beams from the stock room or from the department in which the warps are made up and conveying them to the looms. This system is used only where the beams are heavy, as in the case of beams for wide machines and also for heavy fabrics. This same hoisting and conveying system is also used for carrying cloth from the weave room to the chutes or conveyors which convey the woven fabric to the finishing department. (Edwin H. Marble, President, Curtis & Marble Machine Co., Worcester, Mass.)

(*b*) Conveying and hoisting systems are used rather extensively in textile mills. Pneumatic systems are used for conveying raw cotton from openers to bins, and wool stock, both dyed and raw, to storage bins. Wool can be moved considerable distances in this manner. Lattice conveyors also are used. Pneumatic and hydraulic hoists are used for operating various types of dyeing machines. (A. R. Jealous, Assistant Works Manager, The Clark Thread Co., Newark, N. J.)

BUILDING CONSTRUCTION

T-3 Why do textile manufacturers seem to favor buildings of slow-burning construction rather than concrete?

Slow-burning construction is cheaper; wood floors are more comfortable to work on than concrete; wood floors and ceilings are more convenient for attaching shafting, machinery, sheet iron, wiring, etc., than concrete. The latter is especially true when changes are frequent. Wood floors are more easily repaired when worn than concrete. (A. R. Jealous, Assistant Works Manager, The Clark Thread Co., Newark, N. J.)

LARGE LOOMS

T-4 What is the reed width of the largest loom ever built and what is woven on that loom?

(*a*) The largest loom the writer has ever seen is 240 in. (20 ft.) wide and is in a duck plant, weaving paper felts. (Earle R. Stall, Textile Engineer, J. E. Sirrine & Co., Greenville, S. C.)

(*b*) Looms with 400 to 480 in. of weaving space have been built for the manufacture of paper-makers' felts. It is said that foreign looms with wider weaving space have been built, but outside the manufacture of broad rugs, 20 to 30 ft. wide, the wide looms are used almost wholly in the manufacture of the so-called paper-makers' felts. (Edwin H. Marble, President, Curtis & Marble Machine Co., Worcester, Mass.)

PUMPS

T-5 For what purposes are pumps employed in the textile industry and what types are most suitable?

These may be divided into three classes, as follows: First, fire pumps, which are usually of the reciprocating type; second, pumps used for creating pressure in water systems, and consisting of either the rotary or the reciprocating type; and third, pumps used for creating vacuums, which can be subdivided into rotary and reciprocating types. However, conditions in the textile industry vary so greatly that pumps of special construction or specially adapted are required in many cases. (Edwin H. Marble, President, Curtis & Marble Machine Co., Worcester, Mass.)

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision in the Rules in its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

During the past two years the Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals, and all deleted matter in smaller type.

Revisions and Addenda

PAR. S–97. REVISE LAST SENTENCE OF SECTION *a* TO READ:

For IRON AND steel tubes over $2^1/_2$ in. in diameter and up to $3^3/_4$ in., inclusive, the width of the flange shall be $^3/_8$ in., and for tubes over $3^3/_4$ in. the width of the flange shall be 10 per cent of the outside diameter.

PAR. S–99. REVISE REQUIREMENT FOR CHARCOAL-IRON TUBES IN THIS PARAGRAPH TO READ:

Charcoal-iron tubes: No. 10 B.W.G. or lighter, to a height of $1^1/_8$ in.; if heavier than No. 10 B.W.G., to a height of $1^1/_2$–$1^3/_4$ in. Slight surface checks shall not be a cause for rejection.

PAR. S–101. REVISE FOOTNOTE REFERRED TO, TO READ:

[1] A solution of 10 PER CENT HYDROCHLORIC ACID (SP. GR. 1.19), 30 PER CENT SULPHURIC ACID (SP. GR. 1.84), AND 60 PER CENT WATER; OR 25 PER CENT NITRIC ACID (SP. GR. 1.42) AND 75 PER CENT WATER, [two parts water, one part HCl (sp. gr. 1.20), and one part H_2SO_4 (sp. gr. 1.84)] is recommended for the etch test.

SPECIFICATIONS FOR STEEL PIPE. REVISE TITLE TO READ: Specifications for WELDED AND SEAMLESS Steel Pipe.

PAR. S–110. REVISE TO READ:

S–110. *Material Covered.* These specifications cover "standard," [and] "extra strong" AND "DOUBLE EXTRA STRONG" welded and seamless steel pipe [but not "double extra strong" pipe]. Pipe ordered under these specifications are intended for bending, flanging and other special purposes.

PAR. S–113. REVISE TO READ:

S–113. *Tension Tests.* The material shall conform to the following minimum requirements as to tensile properties:

	Welded		Seamless	
	Bessemer	Open-hearth	Open-hearth LOW CARBON	OPEN-HEARTH MEDIUM CARBON
Tensile strength, lb. per sq. in....	50,000	45,000	48,000	62,000
Yield point, lb. per sq. in.....	30,000	25,000	26,500	35,000
Elongation in 8 in., per cent....	18	20	18	...
ELONGATION IN 2 IN., PER CENT.	...	...	40	25

PAR. S–115. INSERT NEW SECTION *c* TO READ:

c THE FLATTENING TEST WILL NOT BE REQUIRED ON DOUBLE EXTRA STRONG PIPE.

TABLE S–4. ADD TWO COLUMNS OF REQUIREMENTS FOR DOUBLE EXTRA STRONG PIPE TO READ:

"DOUBLE EXTRA STRONG" PIPE	
BUTT-WELD	LAP-WELD AND SEAMLESS
....	....
....	....
....	....
700	....
700	....
700	....
2200	....
2200	3000
2200	3000
2200	3000
2200	3000
....	2500
....	2500
....	2000
....	2000
....	2000
....	2000
....	2000
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PAR. S–116. REVISE TO READ:

S–116. *Bend Tests.* For pipe 2 in. or under in diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. THIS TEST WILL NOT BE REQUIRED ON DOUBLE EXTRA STRONG PIPE OVER $1^1/_4$ IN. IN DIAMETER.

PAR. S–121. REVISE TO READ:

S–121. *Permissible Variations.* The weight of the pipe shall not vary more than 5 per cent FOR STANDARD AND EXTRA STRONG PIPE NOR MORE THAN 10 PER CENT FOR DOUBLE EXTRA STRONG PIPE from that specified in Table S–5.

PAR. S–122. REVISE SECTION *b* TO READ:

b Extra strong AND DOUBLE EXTRA STRONG pipe shall be in random lengths of 12 to 22 ft. Five per cent may be in lengths of 6 to 12 ft.

TABLE S–5. ADD TWO COLUMNS OF REQUIREMENTS FOR DOUBLE EXTRA STRONG PIPE TO READ:

"DOUBLE EXTRA STRONG" PIPE	
THICKNESS, IN.	WEIGHT OF PIPE PER LINEAR FOOT, PLAIN ENDS, LB.
.....	.....
.....	.....
.....	.....
0.294	1.71
0.308	2.44
0.358	3.66
0.382	5.21
0.400	6.41
0.436	9.03
0.552	13.70
0.600	18.583
0.636	22.85
0.674	27.54
0.710	32.53
0.750	38.55
0.864	53.16
0.875	63.08
0.875	72.42
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

PAR. S–124. REVISE SECTION *b* TO READ:

b Extra strong welded pipe and standard and extra strong seamless pipe AND ALL DOUBLE EXTRA STRONG PIPE shall be furnished with plain ends.

PAR. S–127. REVISE TO READ:

S–127. *Material Covered.* These specifications cover "standard," [and] "extra strong" AND "DOUBLE EXTRA STRONG" welded wrought-iron pipe [but not "double extra strong" pipe].

TABLE S–6. ADD TWO COLUMNS FOR REQUIREMENTS FOR DOUBLE EXTRA STRONG PIPE TO READ:

"DOUBLE EXTRA STRONG" PIPE	
THICKNESS, IN.	WEIGHT OF PIPE PER LINEAR FOOT, PLAIN ENDS, LB.
.....	.....
.....	.....
.....	.....
0.294	1.71
0.308	2.44
0.358	3.66
0.382	5.21
0.400	6.41
0.436	9.03
0.552	13.70
0.600	18.583
0.636	22.85
0.674	27.54
0.710	32.53
0.750	38.55
0.864	53.16
0.875	63.08
0.875	72.42
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

PAR. S–193. OMIT COLUMN REFERRING TO INSIDE DIAMETER, AND ADD TWO COLUMNS COVERING REQUIREMENTS FOR EXTRA STRONG PIPE TO READ:

EXTRA STRONG PIPE	
THICKNESS, IN.	NOMINAL WEIGHT, LB. PER FOOT OF LENGTH
0.100	0.371
0.123	0.624
0.127	0.847
0.149	1.25
0.157	1.71
0.182	2.51
0.194	3.46
0.203	4.19
0.221	5.79
0.280	8.84
0.304	11.82
0.321	14.37
0.341	17.25
0.375	21.10
0.375	23.67
0.437	32.93
0.500	43.34
0.500	49.42
0.500	55.56
0.500	62.40

PAR. S–209. OMIT COLUMN REFERRING TO INSIDE DIAMETER, AND ADD TWO COLUMNS COVERING REQUIREMENTS FOR EXTRA STRONG PIPE, TO READ:

EXTRA STRONG PIPE	
THICKNESS, IN.	NOMINAL WEIGHT, LB. PER FOOT OF LENGTH
0.100	0.353
0.123	0.593
0.127	0.805
0.149	1.19
0.157	1.62
0.182	2.39
0.194	3.30
0.203	3.99
0.221	5.51
0.280	8.41
0.304	11.24
0.321	13.67
0.341	16.41
0.375	20.07
0.375	22.52
0.437	31.32
0.500	41.23
0.500	47.02
0.500	52.81
0.500	59.32

SPECIFICATIONS FOR CARBON-STEEL CASTINGS FOR VALVES, FLANGES AND FITTINGS FOR HIGH-TEMPERATURE SERVICE.

THE FOLLOWING NEW A.S.T.M. SPECIFICATION (A–95–26T) IS TO BE INCLUDED:

1 Material Covered. These specifications cover carbon-steel castings for valves, flanges and fittings for high-temperature service (Note 1).

2 Process. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, converter, or crucible.

3 Heat Treatment. *a* All castings shall receive a heat treatment proper to the design and chemical composition of the castings.

b Heat treatment, unless otherwise specified by the purchaser, may consist of annealing, or of normalizing, or of normalizing followed by annealing, or of normalizing followed by a draw-back to a temperature below the critical range. No castings which have been quenched in any liquid medium shall be offered under these specifications.

c Annealing. The procedure for annealing shall consist in allowing the castings to cool, after pouring, to a temperature below the critical range. They shall then be uniformly reheated to the proper temperature to refine the grain and allowed to cool uniformly in the furnace.

d Normalizing. The procedure for normalizing shall consist in allowing the castings to cool, after pouring, to a temperature below the critical range. They shall then be reheated to the proper temperature to refine the grain and allowed to cool in still air.

4 Chemical Composition. *a* The castings shall conform to the following requirements as to chemical composition, except that the following limitations for carbon, manganese and silicon are intended to show desired composition and are not to be used for rejection:

Carbon	0.15–0.40 per cent
Manganese	not under 0.50 per cent
Silicon	not under 0.20 per cent
Phosphorus	not over 0.05 per cent
Sulphur	not over 0.05 per cent

b Manufacturers submitting proposals to furnish material under these specifications shall specify, with their proposals, the limits of carbon, manganese and silicon which they will accept as a basis for rejection.

5 Ladle Analyses. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 4. This analysis shall be made from drillings taken at least $1/4$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 4.

6 Check Analyses. Analyses may be made by the purchaser from the broken tension-test specimen or from a casting representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 4. Samples for analysis shall be taken not less than $1/4$ in. beneath the surface, except in the case of castings which are too thin, and shall be taken in such a manner as not to impair the usefulness of the casting.

7 Tension Tests. *a* The castings shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	70,000
Yield point, lb. per sq. in.	36,000
Elongation in 2 in., per cent	22
Reduction of area, per cent	30

b The yield point shall be determined by the drop of the beam of the testing machine at a crosshead speed not to exceed $1/8$ in. per minute. The tensile strength shall be determined at a speed not to exceed $1\frac{1}{2}$ in. per minute.

8 Bend Test. *a* Bend tests shall be required for castings only when so specified in the order.

b When a bend test is specified, the test specimens shall stand being bent cold through an angle of 90 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

9 Test Specimens. *a* Tension-test specimens, and, when a bend test is specified, bend-test specimens, shall be taken from test bars cast attached to the castings where practicable. If the design of the castings is such that test bars should not be attached to the castings, the test bars shall be cast attached to special blocks, a sufficient number of which shall be provided for each lot of castings. Test bars from which tension- and bend-test specimens are to be taken shall remain attached to the castings or blocks they represent through heat treatment and until presented for inspection. Test bars shall be provided in sufficient numbers to furnish the tests required in Section 10.

b If satisfactory to the manufacturer and inspector, tension-test specimens may be cut from heat-treated castings instead of from test bars.

c Tension-test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

d Bend-test specimens shall be machined to 1 by 1/2 in. in section with the corners rounded to a radius of not over 1/16 in.

10 Number of Tests. *a* One tension test and, when specified, one bend test shall be made from each melt in each heat-treatment charge and, when specified, from each casting weighing 500 lb. or over.

b If any test specimen shows defective machining or develops flaws, it may be discarded; in which case another specimen from the same lot shall be substituted.

c If the percentage of elongation of any tension-test specimen is less than that specified in Par. 7 *a*, and any part of the fracture is more than 3/4 in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

11 Retests. If the results of the physical tests for any lot do not conform to the requirements specified, such lot may be re-treated, but not more than twice. Retests shall be made as specified in Pars. 7 and 8.

12 Workmanship. The castings shall conform substantially to the shapes and sizes indicated by the patterns and drawings submitted by the purchaser.

13 Finish. *a* The castings shall be free from injurious defects.

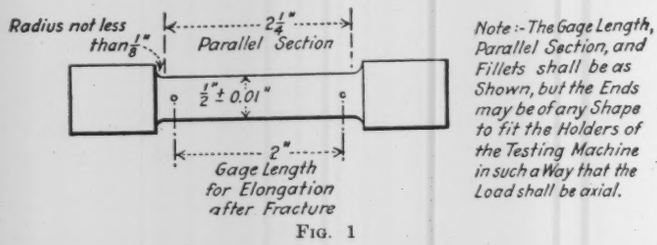


FIG. 1

Welding. *b* Defects which do not impair the strength of the castings may be welded by an approved process. The defects shall be cleaned out to solid metal, before welding, and when so required by the inspector, shall be submitted to him in this condition for his approval. All castings shall be heat-treated after welding in accordance with the requirements in Par. 3.

14 Inspection. *a* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications.

b If, in the case of important castings for special purposes, surface inspection in the green state is required, this shall be so specified in the order.

c All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

15 Rejection. *a* Unless otherwise specified, any rejection based on tests made in accordance with Par. 6 shall be reported within five working days from the receipt of samples.

b Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer shall be notified.

16 Rehearing. Samples tested in accordance with Par. 6, which represent rejected castings, shall be preserved for two weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 750 deg. fahr. (400 deg. cent.); or at the discretion of the designing engineer higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Socitey of the Valve and Fittings Industry and The American Society of Mechanical Engineers, and organized under the procedure of the American Engineering Standards Committee.

SPECIFICATIONS FOR CARBON-STEEL AND ALLOY-STEEL FORGINGS

THE FOLLOWING NEW A.S.T.M. SPECIFICATION (A18-21) IS TO BE MADE AN ADDENDA TO THE CODE.

1 Material Covered. *a* These specifications cover the various classes of carbon-steel and alloy-steel forgings now commonly used and not covered by other existing specifications of the American Society for Testing Materials.

b The purposes for which these classes are frequently used are as follows:

Class A, for forgings which may be welded or case-hardened;

Class B, for mild-steel forgings for structural purposes, for minor ship fittings, etc.;

Class C, for mild-steel forgings for structural purposes, for ships, etc.;

Classes D, E, F, G, H and *I*, for various machinery forgings, choice depending upon design and upon the stresses and services to be imposed.

Classes K, L and *M*, for various machinery forgings, choice depending upon design and upon the stresses and services to be imposed, and upon the character of machining operations to be done.

2 Process. The steel shall be made by either or both the following processes: open-hearth or electric furnace.

3 Discard. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4 Prolongations for Tests. The manufacturer and the purchaser shall agree upon forgings on which a prolongation for test purposes shall be provided.

5 Boring. If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6 Heat Treatment. Heat treatment, if required, shall consist of either annealing or quenching and tempering, as specified.

a The procedure to be followed in annealing shall consist in allowing the objects, immediately after forging, to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an "annealing charge"), and allowed to cool uniformly.

b The procedure to be followed in quenching and tempering shall consist in allowing the objects, immediately after forging, to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "quenching charge"), and quenched in some medium under substantially uniform conditions for each quenching charge. Finally, they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a "tempering charge"), and allowed to cool uniformly.

7 Chemical Composition. *a* The steel shall conform to the following requirements as to chemical composition:

Elements considered	Classes A	B, C, D, E, F, G	H, I	K, L	M
Manganese, per cent	0.30–0.55	0.40–0.80	0.40–0.80	.....	.....
Phosphorus, per cent:					
Acid	not over 0.05	not over 0.05	not over 0.04	not over 0.05	not over 0.04
Basic	not over 0.05	not over 0.05	not over 0.04	not over 0.04	not over 0.04
Sulphur, per cent	not over 0.05	not over 0.05	not over 0.05	not over 0.05	not over 0.05
Nickel, per cent	.....	.....	not under 3.00	.....	.....

b The composition of alloy steel, other than phosphorus and sulphur, to be used in forgings of Classes K, L, and M, shall be agreed upon by the manufacturer and the purchaser.

8 Ladle Analyses. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese and the elements specified in Par. 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Par. 7.

9 Check Analyses. An analysis may be made by the purchaser from a forging representing each melt. The chemical composition

TABLE I TENSILE PROPERTIES (CLASSES A TO F, INCLUSIVE)

FOR FORGINGS WHOSE MAXIMUM OUTSIDE DIAMETER OR OVERALL THICKNESS IS NOT OVER 20 IN.

CLASS	SIZE Outside diameter or overall thickness	Tensile strength, min. (except Class A), lb. per sq. in.	Yield point, min., lb. per sq. in.	Elongation in 2 in., min., per cent: Inverse ratio	Elongation in 2 in., min., per cent: Not under	Reduction of area, min., per cent: Inverse ratio	Reduction of area, min., per cent: Not under
A UNTREATED	All sizes	47,000 to 60,000	0.5 tens. str.	1,500,000 / Tens. str.	..	2,500,000 / Tens. str.	..
B UNTREATED	Not over 12 in.	60,000	0.5 tens. str.	1,550,000 / Tens. str.	22	2,400,000 / Tens. str.	35
	Over 12 to 20 in., inclusive	60,000	0.5 tens. str.	1,480,000 / Tens. str.	21	2,220,000 / Tens. str.	32
C ANNEALED	Not over 12 in.	60,000	0.5 tens. str.	1,700,000 / Tens. str.	25	2,700,000 / Tens. str.	38
	Over 12 to 20 in., inclusive	60,000	0.5 tens. str.	1,600,000 / Tens. str.	24	2,520,000 / Tens. str.	36
D UNTREATED	Not over 8 in.	75,000	0.5 tens. str.	1,600,000 / Tens. str.	18	2,200,000 / Tens. str.	24
	Over 8 to 12 in., inclusive	75,000	0.5 tens. str.	1,500,000 / Tens. str.	17	2,000,000 / Tens. str.	22
	Over 12 to 20 in., inclusive	75,000	0.5 tens. str.	1,400,000 / Tens. str.	16	1,800,000 / Tens. str.	20
E ANNEALED	Not over 8 in.	75,000	0.5 tens. str.	1,800,000 / Tens. str.	20	2,800,000 / Tens. str.	33
	Over 8 to 12 in., inclusive	75,000	0.5 tens. str.	1,725,000 / Tens. str.	19	2,640,000 / Tens. str.	31
	Over 12 to 20 in., inclusive	75,000	0.5 tens. str.	1,650,000 / Tens. str.	18	2,400,000 / Tens. str.	29
F ANNEALED	Not over 8 in.	80,000	0.5 tens. str.	1,800,000 / Tens. str.	20	2,800,000 / Tens. str.	32
	Over 8 to 12 in., inclusive	80,000	0.5 tens. str.	1,725,000 / Tens. str.	19	2,640,000 / Tens. str.	30
	Over 12 to 20 in., inclusive	80,000	0.5 tens. str.	1,650,000 / Tens. str.	18	2,400,000 / Tens. str.	28

TABLE II TENSILE PROPERTIES (CLASSES G, H, AND I)

FOR FORGINGS WHOSE MAXIMUM OUTSIDE DIAMETER OR THICKNESS IS NOT OVER 10 IN. WHEN SOLID, AND NOT OVER 20 IN. WHEN BORED

CLASS	SIZE	Tensile strength, min., lb. per sq. in.	Elastic limit, min., lb. per sq. in.	Elongation in 2 in., min., per cent: Inverse ratio	Elongation in 2 in., min., per cent: Not under	Reduction of area, min., per cent: Inverse ratio	Reduction of area, min., per cent: Not under
G QUENCHED AND TEMPERED	Up to 4 in. in outside diameter or thickness, 2-in. max. wall	90,000	55,000	2,100,000 / Tens. str.	20.5	4,000,000 / Tens. str.	39
	Over 4 to 7 in. in outside diameter or thickness, 3½-in. max. wall	85,000	50,000	2,000,000 / Tens. str.	20.5	3,800,000 / Tens. str.	39
	Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall	85,000	50,000	1,900,000 / Tens. str.	19.5	3,600,000 / Tens. str.	37
	Outside diameter or thickness not over 20 in., 5- to 8-in. wall	82,500	48,000	1,800,000 / Tens. str.	19	3,400,000 / Tens. str.	36

FOR FORGINGS WHOSE MAXIMUM OUTSIDE DIAMETER OR OVERALL THICKNESS IS NOT OVER 20 IN.

H NICKEL STEEL, ANNEALED	Outside diameter or overall thickness not over 12 in.	80,000	50,000	2,000,000 / Tens. str.	22	3,600,000 / Tens. str.	40
	Outside diameter or overall thickness over 12 to 20 in., inclusive	80,000	50,000	1,900,000 / Tens. str.	21	3,400,000 / Tens. str.	38

FOR FORGINGS WHOSE MAXIMUM OUTSIDE DIAMETER OR THICKNESS IS NOT OVER 10 IN. WHEN SOLID, AND NOT OVER 20 IN. WHEN BORED

I NICKEL STEEL, QUENCHED AND TEMPERED	Up to 4 in. in outside diameter or thickness, 2-in. max. wall	100,000	70,000	2,200,000 / Tens. str.	20	4,500,000 / Tens. str.	41
	Over 4 to 7 in. in outside diameter or thickness, 3½-in. max. wall	100,000	65,000	2,100,000 / Tens. str.	20	4,300,000 / Tens. str.	41
	Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall	90,000	60,000	2,000,000 / Tens. str.	20	4,100,000 / Tens. str.	41
	Outside diameter or thickness not over 20 in., 5- to 8-in. wall	85,000	55,000	1,900,000 / Tens. str.	20	3,900,000 / Tens. str.	41

TABLE III TENSILE PROPERTIES (CLASSES K, L AND M)

FOR FORGINGS WHOSE MAXIMUM OUTSIDE DIAMETER OR THICKNESS IS NOT OVER 10 IN. WHEN SOLID, AND NOT OVER 20 IN. WHEN BORED

CLASS	SIZE	Tensile strength, lb. per sq. in.	Elastic limit, min., lb. per sq. in.	Elongation in 2 in., min., per cent	Reduction of area, min., per cent
K ALLOY STEEL, QUENCHED AND TEMPERED	Up to 2 in. in outside diameter or thickness, 1-in. max. wall	95,000–115,000	70,000	20	50
	Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall	90,000–110,000	65,000	20	50
	Over 4 to 7 in. in outside diameter or thickness, 3½-in. max. wall	90,000–110,000	65,000	20	50
	Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall	90,000–110,000	65,000	20	50
	Outside diameter or thickness not over 20 in., 5- to 8-in. wall	85,000–105,000	60,000	20	50
L ALLOY STEEL, QUENCHED AND TEMPERED	Up to 2 in. in outside diameter or thickness, 1-in. max. wall	105,000–125,000	80,000	20	50
	Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall	100,000–120,000	75,000	20	50
	Over 4 to 7 in. in outside diameter or thickness, 3½-in. max. wall	100,000–120,000	75,000	20	50
	Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall	100,000–120,000	75,000	18	45
	Outside diameter or thickness not over 20 in., 5- to 8-in. wall	95,000–115,000	70,000	18	45
		Minimum			
M ALLOY STEEL, QUENCHED AND TEMPERED	Up to 2 in. in outside diameter or thickness, 1-in. max. wall	125,000	105,000	16	50
	Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall	115,000	95,000	16	45
	Over 4 to 7 in. in outside diameter or thickness, 3½-in. max. wall	110,000	85,000	16	45
	Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall	100,000	75,000	18	45
	Outside diameter or thickness not over 20 in., 5- to 8-in. wall	100,000	70,000	18	45

thus determined shall conform to the requirements specified in Par. 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings; or turnings may be taken from a test specimen.

10 Tension Tests. *a* The forgings shall conform to the requirements as to tensile properties specified in Tables I, II, and III.

b The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

c The yield point shall be determined by the drop of the beam of the testing machine.

d The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

e Tests of forgings shall be made only after final treatment.

11 Tension-Test Specimens. *a* Tension-test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross-section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

b The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

c The specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

12 Number of Tests. Unless otherwise specified by the purchaser, tests shall be made as follows:

a For untreated forgings, one tension test shall be made from each melt.

b For annealed forgings, one tension test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension test shall be made from each melt.

c For quenched and tempered forgings, one tension test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension test shall be made from each melt.

d If more than one class of forgings by size is represented in any lot, one tension test from a forging of each class by size shall be made as specified in Pars. 10 and 11.

e If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

f If the percentage of elongation of any test specimen is less than that specified in Par. 10 *a* and any part of the fracture is more than $^3/_4$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

13 Retests. If the results of the physical tests of any test lot of forgings do not conform to the requirements specified, the manufacturer may re-treat such lot one or more times and retests shall be made as specified in Par. 12.

14 Workmanship. The forgings shall conform to the sizes and shapes specified by the purchaser. When centered, 60-deg. centers with clearance drilled for points shall be used.

15 Finish. The forgings shall be free from injurious defects and shall have a workmanlike finish.

16 Marking. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

17 Inspection. *a* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

b The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

c Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

18 Rejection. *a* Unless otherwise specified, any rejection based on tests made in accordance with Par. 17 *b* shall be reported within five working days from the receipt of samples.

b Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

19 Rehearing. Samples tested in accordance with Par. 17 *b*, which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in Mechanical Engineering.

Below are given interpretations of the Committee in Cases Nos. 530 to 533, inclusive, as formulated at the meeting of September 24, 1926, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

Case No. 530

(In the hands of the Committee)

Case No. 531

Inquiry: Is it the intent of Par. U-23*b* of the Code that where circumferentially welded joints are permitted for vessels of diameters up to 72 in. when at least 75 per cent of the load on a flat head is supported by tubes or stays, through stays must be used in order to afford support for the heads such as is provided by tubes, or would diagonal stays between the heads and the shell be permissible?

Reply: It is the intent of the Code that where welded circumferential joints are used on pressure vessels of diameters exceeding 48 in. and not exceeding 72 in. as provided for in Par. U-23*b*, the support of 75 per cent of the load on a flat head must be provided either by tubes or through stays extending from head to head.

Case No. 532

Inquiry: Is it permissible, under the Miniature Boiler Section of the Code, to construct water-tube-type boilers for operation at 60 lb. per sq. in. with removable heads of pressed-steel construction in which the heads are drawn from $^3/_{16}$-in. steel plate? Par.

M-3 of the Code permits $^3/_{16}$ in. thickness for seamless shells, but in this construction the heads are bolted to gasket surfaces on the tube sheets which are in excess of the $^5/_{16}$-in. head thickness required by Par. M-3.

Reply: There is nothing in the Code to limit the thickness of such removable heads of miniature boilers. The limit of thickness in Par. M-3 applies to shell plates only.

CASE NO. 533

Inquiry: Is it permissible, under the Code, to utilize a studded connection for connecting pipe outlets larger than 3 in. pipe size direct to flat surfaces of shells or heads of boilers, without a nozzle or saddle flange? Par. P-268 is specific in its requirement for a nozzle or saddle flange riveted to the boiler, but it has long been customary to attach flanged-pipe outlet connections direct to the boiler heads where the surface is flat enough to apply a gasket and the thickness of the shell is sufficient to permit insertion of studs.

Reply: Par. P-268 requires that nozzles and saddle flanges shall be riveted to the boiler shell or head, but it was not the intent to prohibit the attachment of flange-pipe outlets direct to shells or heads where a surface flat enough for the application of a gasket is available and the thickness of the plate is sufficient for insertion of studs. It is the opinion of the Committee, however, that for the insertion of studs the thickness of the plate should be at least equal to the diameter of the bolt that would be required for the flange connection. A revision of Par. P-268 is contemplated which will provide for such studded pipe outlet connections, and until this revision is completed it is the opinion of the Committee that studded pipe outlet connections as above outlined may be used with safe results.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

The Savenius Wing Rotor

TO THE EDITOR:

I happened to read the article about the Savenius wing rotor in the November, 1925, issue of MECHANICAL ENGINEERING and failed to find any mention of an important difference and disadvantage of the Savenius rotor compared with the Flettner rotor, when used for ship propulsion.

The point is this: Inasmuch as the rotation of the Savenius rotor is determined definitely by the position of the semi-cylindrical wings, the direction of the Magnus force is also determined for a particular direction of the wind. This means that in case of a north wind the Flettner rotor ship can be propelled either eastward or westward by changing the rotation of the cylinders, whereas a Savenius rotor ship would be driven either eastward only or westward only, depending upon the rotation of the cylinders, which is fixed for a given ship. (I do not presume, and the author of article does not mention, that the wings can be shifted relatively at will, once mounted.) Should the wings be installed as shown in Fig. 2 of the article, the ship would, in a north wind, receive an eastward Magnus force and could not travel westward unless by tacking.

THOS. BOCEK.[1]

New York, N. Y.

[Commenting on Mr. Bocek's communication which was referred to him, Professor Klemin, the author of the article in question, writes that Mr. Bocek's point is an excellent one, but that it is his—Professor Klemin's—impression that the Savenius rotor was to be used for ventilation purposes and not for ship propulsion.—EDITOR.]

[1] J. G. White Engineering Corp.

Heat Treatment of Chains

IN THE latest annual report of the National Physical Laboratory reference is made to work which is being carried out in connection with the heat treatment of chains, which is a practice—in some cases a statutory requirement—whose object is the removal or partial removal of the hardening and embrittlement produced by the strains and shocks to which chains are subjected in practice. The main object of the present research is to study the effects of, first, low-temperature annealing (650 to 760 deg cent.), and, secondly, normalizing, upon the mechanical properties of chains which have been subjected to varying degrees of plastic strain.

The work performed to date includes the following: A $^3/_4$-in. chain, in the condition in which it was received from the manufacturers and the proving house, has been subjected to a number of overstrainings produced by either static tensile loading or impact tensile loading. One, two, and three overstrainings were employed, with intermediate and final heat treatments. The tests made led to the following conclusions:

1 Where static tensile overstraining forces were employed: (*a*) The total energy to fracture of a chain subjected to repeated straining, followed after each strain by either annealing or normalizing, is much greater than the energy to fracture of a sample which has not been subjected to intermediate heat treatment. The final breaking load remains, however, generally unchanged. Normalizing possesses no advantages over annealing in this respect, both being regarded as satisfactory treatments. (*b*) Although repeated overstrainings and annealings produce a somewhat reduced value of the tensile strength of the material of which the chain is composed, no indication of any "shortness" is disclosed by a static tensile test. (*c*) Tensile impact tests made on specimens cut from links and normalized on receipt at the laboratory showed that the energy absorbed to fracture was somewhat reduced by a combination of overstrainings and annealings. In no case, however, did this value fall below that of the material in the condition "as received" (i.e., after manufacture and a single "proofing"). Intermediate and/or a final normalizing treatment somewhat improved this value. (*d*) Notched-bar tests on specimens cut from chain links showed that the energy absorbed to fracture is greatly reduced by repeated overstrainings followed by annealings. A final normalizing process tends to restore the material.

2 Where tensile impact overstraining forces were employed: (*a*) In the tensile impact tests to destruction the fact was clearly brought out that a progressive deterioration of the welded portions of the link took place due to the shocks employed in the overstraining processes. In nearly every case fracture finally occurred at a welded joint. The intermediate heat treatment, whether normalizing or annealing, had of course no effect on this deterioration. In the few cases where failure did not occur at the weld the values of the energies to fracture showed that combinations of overstrainings and annealings had not produced any brittleness in the chain as a unit. (*b*) As in the case of chains subjected to static tensile overstraining, tensile and tensile impact tests made on specimens cut from chain links failed to show any marked deterioration in the properties of the material due to combinations of overstraining and annealing. (*Mechanical World*, vol. 80, no. 2079, November 5, 1926, p. 363.)

Congress to Debate Muscle Shoals Disposal

EFFORT to reach a decision as to the disposal of Muscle Shoals will be one of the outstanding issues at the approaching session of Congress, in the opinion of leaders interested in this legislation. Since those favoring Government ownership will probably be augmented in the 70th Congress, advocates of sale to private parties are preparing to bring the question to final vote before the session ends on March 4, 1927. The Government-operation advocates, on the other hand, will make a determined fight to prevent a vote until the next Congress.

Significant in connection with this legislation is the Boulder Canyon Bill, which proposes to provide for a gigantic development of the Colorado River by the Government. Proponents of Government operation feel that if this can be gotten through it will provide a precedent for Government operation of Muscle Shoals.

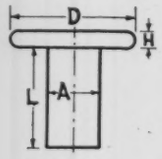
Tentative American Standards for Tinners', Coopers', and Belt Rivets, Small Rivets, and Plow Bolts

IN MARCH, 1922, the American Engineering Standards Committee authorized the organization of a Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions. This work is sponsored by the Society of Automotive Engineers and The American Society of Mechanical Engineers.

The Sectional Committee consists of 50 representatives of 29 national organizations and is composed of manufacturers, consumers, and general interests who organized Sub-Committees to standardize on the following:

Rivets
Wrench-Head Bolts and Nuts and Wrench Openings
Slotted-Head Bolts
Track Bolts
Round Unslotted-Head Bolts
Plow Bolts
Body Dimensions and Materials
Nomenclature.

Now that the Sectional Committee has approved the proposed standard on small rivets ($^7/_{16}$ in. nominal diameter and under), and also those on tinners', coopers' and belt rivets, and on plow bolts, they are all three before the two sponsor bodies for approval and transmission to the American Engineering Standards Committee. Copies of these proposed standards in page-proof form are now available to those especially interested and may be procured by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.



Tinners', Coopers', and Belt Rivets

TABLE 1 TINNERS' RIVETS—SEE SKETCH ABOVE

Size No.	*A* Diameter of body	*D* Diameter of head	*H* Height of head	*L* Length under head
8 oz.	0.09	0.203	0.027	0.15
12 oz.	0.10	0.225	0.030	0.18
1 lb.	0.11	0.248	0.033	0.20
1½ lb.	0.13	0.293	0.039	0.23
2 lb.	0.14	0.315	0.042	0.26
2½ lb.	0.15	0.338	0.045	0.28
3 lb.	0.16	0.360	0.048	0.31
4 lb.	0.17	0.383	0.051	0.34
6 lb.	0.20	0.450	0.060	0.39
8 lb.	0.22	0.495	0.066	0.43
10 lb.	0.24	0.540	0.072	0.46
12 lb.	0.26	0.575	0.078	0.50
14 lb.	0.28	0.630	0.084	0.51
16 lb.	0.30	0.675	0.090	0.53

All dimensions given in inches.

Approximate Proportions: $D = 2.25 \times A$; $H = 0.30 \times A$.

Tolerances. The tolerances on the various sizes of coopers' and tinners' rivets shall be those given in the following table:

Size inclusive	Tolerances Plus	Tolerances Minus
8 oz.— 2½ lb.	0.002	0.004
3 lb.—10 lb.	0.003	0.006
12 lb.—16 lb.	0.004	0.008

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

Coopers' Rivets—See Table 2

Approximate Proportions: $D = 2.25 \times A$; $H = 0.30 \times A$; $a = 0.90 \times A$; $E = 0.40 \times A$.

Tolerances. The tolerances on the various sizes of coopers' and tinners' rivets shall be those given in the following table:

Size (Inclusive)	Tolerances Plus	Tolerances Minus
8 oz.— 2½ lb.	0.002	0.004
3 lb.—10 lb.	0.003	0.006
12 lb.—16 lb.	0.004	0.008

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

Belt Rivets

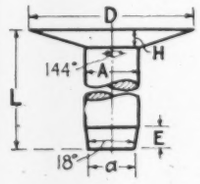


TABLE 3 BELT RIVETS—SEE SKETCH ABOVE

Size No.	*A* Diameter of body	*D* Diameter of head	*H* Depth of head	Included angle (deg.)	*L* Length overall	*E* Length of chamfer	*a* Diameter of tip
7	0.18	0.504	0.54	144	Lengths	0.072	0.162
8	0.16	0.448	0.48	144	to be	0.064	0.144
9	0.15	0.420	0.45	144	from	0.060	0.135
10	0.14	0.392	0.42	144	¾" to	0.056	0.125
11	0.12	0.336	0.36	144	¾" by	0.048	0.108
12	0.10	0.280	0.30	144	¼" incre-	0.040	0.090
13	0.09	0.252	0.27	144	ments	0.036	0.081

All dimensions given in inches.

Approximate Proportions: $D = 2.8 \times A$; $H = 0.3 \times A$; $E = 0.4 \times A$; $a = 0.9 \times A$.

Tolerances. The tolerances on the nominal diameter of belt rivets shall be plus 0.002 in. and minus 0.004 in.

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

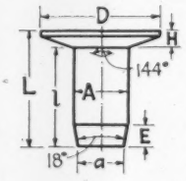
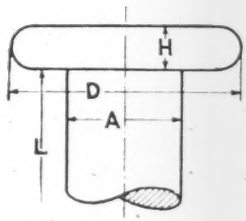


TABLE 2 COOPERS' RIVETS—SEE SKETCH ABOVE

Size No.	*A* Diameter of body	*D* Diameter of head	*H* Height of head	Included angle (deg.)	*l* Length under head	*L* Overall length	*E* Length of chamber	*a* Diameter of tip
1 lb.	0.11	0.248	0.033	144	0.18	0.213	0.044	0.099
1½ lb.	0.13	0.293	0.039	144	0.22	0.259	0.052	0.117
2 lb.	0.14	0.315	0.042	144	0.25	0.292	0.056	0.126
2½ lb.	0.15	0.338	0.045	144	0.28	0.325	0.060	0.135
3 lb.	0.16	0.360	0.048	144	0.31	0.358	0.064	0.144
4 lb.	0.17	0.383	0.051	144	0.34	0.391	0.068	0.153
6 lb.	0.20	0.450	0.060	144	0.40	0.460	0.080	0.180
8 lb.	0.23	0.518	0.069	144	0.50	0.569	0.092	0.207
10 lb.	0.25	0.563	0.075	144	0.53	0.605	0.100	0.225
12 lb.	0.26	0.585	0.078	144	0.53	0.608	0.104	0.234
14 lb.	0.27	0.608	0.081	144	0.56	0.641	0.108	0.243
16 lb.	0.28	0.630	0.084	144	0.59	0.674	0.112	0.252

All dimensions given in inches.



Small Rivets

TABLE 1 FLAT-HEAD RIVETS—SEE SKETCH ABOVE

A Diameter of Shank Nominal	A Maximum	A Minimum	D Diameter of head	H Height of head	L Length under head
3/32—0.094	0.096	0.090	0.190	0.032	Ordered length under head to end
1/8—0.125	0.127	0.121	0.250	0.042	
5/32—0.156	0.158	0.152	0.312	0.052	
3/16—0.188	0.191	0.182	0.374	0.062	
7/32—0.219	0.222	0.213	0.440	0.073	
1/4—0.250	0.253	0.244	0.500	0.083	
9/32—0.281	0.285	0.273	0.562	0.094	
5/16—0.313	0.317	0.305	0.624	0.104	
11/32—0.344	0.348	0.336	0.686	0.114	
3/8—0.375	0.380	0.365	0.750	0.125	
7/16—0.438	0.443	0.428	0.874	0.146	

All dimensions given in inches.

Approximate Proportions: $D = 2.00 \times A$; $H = 0.33 \times A$.

Fillets. Rivets are acceptable with fillets under the head up to 1/32 in. radii.

Tolerances. The tolerances on the nominal diameters of the shanks shall be those given in the following table:

Diameters of shanks (inclusive)	Tolerances Plus	Tolerances Minus
3/32— 5/32	0.002	0.004
3/16— 1/4	0.003	0.006
9/32—11/32	0.004	0.008
3/8— 7/16	0.005	0.010

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

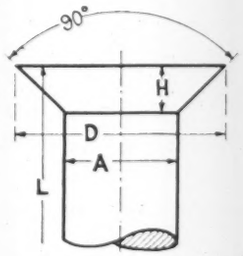


TABLE 2 COUNTERSUNK-HEAD RIVETS—SEE SKETCH ABOVE

A Diameter of Shank Nominal	A Maximum	A Minimum	D Diameter of head	H Depth of head	Included angle (deg.)	L Length overall
3/32—0.094	0.096	0.090	0.176	0.040	90	Ordered length
1/8—0.125	0.127	0.121	0.231	0.053	90	
5/32—0.156	0.158	0.152	0.289	0.066	90	
3/16—0.188	0.191	0.182	0.346	0.079	90	
7/32—0.219	0.222	0.213	0.407	0.094	90	
1/4—0.250	0.253	0.244	0.463	0.106	90	
9/32—0.281	0.285	0.273	0.520	0.119	90	
5/16—0.313	0.317	0.305	0.577	0.133	90	
11/32—0.344	0.348	0.336	0.635	0.146	90	
3/8—0.375	0.380	0.365	0.694	0.159	90	
7/16—0.438	0.443	0.428	0.808	0.186	90	

All dimensions given in inches.

Approximate Proportions: $D = 1.850 \times A$; $H = 0.425 \times A$.

Tolerances. The tolerances on the nominal diameters of the shanks shall be those given in the following table:

Diameters of shanks (inclusive)	Tolerances Plus	Tolerances Minus
3/32— 5/32	0.002	0.004
3/16— 1/4	0.003	0.006
9/32—11/32	0.004	0.008
3/8— 7/16	0.005	0.010

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

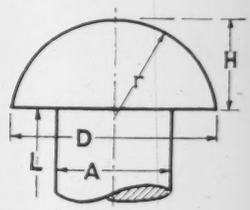


TABLE 3 BUTTON-HEAD RIVETS—SEE SKETCH ABOVE

A Diameter of Shank Nominal	A Maximum	A Minimum	D Diameter of head	H Height of head	r Radius of head	L Length under head
3/32—0.094	0.096	0.090	0.166	0.071	0.084	Ordered length under head to end
1/8—0.125	0.127	0.121	0.219	0.094	0.111	
5/32—0.156	0.158	0.152	0.273	0.117	0.138	
3/16—0.188	0.191	0.182	0.327	0.140	0.166	
7/32—0.219	0.222	0.213	0.385	0.165	0.195	
1/4—0.250	0.253	0.244	0.438	0.188	0.221	
9/32—0.281	0.285	0.273	0.492	0.211	0.249	
5/16—0.313	0.317	0.305	0.546	0.234	0.276	
11/32—0.344	0.348	0.336	0.600	0.257	0.304	
3/8—0.375	0.380	0.365	0.656	0.281	0.332	
7/16—0.438	0.443	0.428	0.765	0.328	0.387	

All dimensions given in inches.

Approximate Proportions: $D = 1.750 \times A$; $H = 0.750 \times A$; $r = 0.885 \times A$.

Fillets. Rivets other than the countersunk type are acceptable with fillets under the head up to 1/32 in. radii.

Tolerances. The tolerances on the nominal diameters of the shanks shall be those given in the following table:

Diameters of shanks (inclusive)	Tolerances Plus	Tolerances Minus
3/32— 5/32	0.002	0.004
3/16— 1/4	0.003	0.006
9/32—11/32	0.004	0.008
3/8— 7/16	0.005	0.010

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

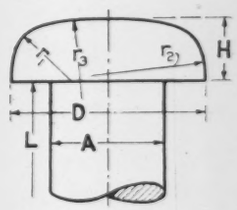


TABLE 4 PAN-HEAD RIVETS—SEE SKETCH ABOVE

A Diameter of Shank Nominal	A Maximum	A Minimum	D Diameter of head	H Height of head	r Radii of Head— r_1	r_2	r_3	L Length under head
3/32—0.094	0.096	0.090	0.163	0.054	0.030	0.080	0.326	Ordered length under head to end
1/8—0.125	0.127	0.121	0.215	0.072	0.039	0.106	0.429	
5/32—0.156	0.158	0.152	0.268	0.089	0.049	0.133	0.535	
3/16—0.188	0.191	0.182	0.321	0.107	0.059	0.159	0.641	
7/32—0.219	0.222	0.213	0.378	0.126	0.069	0.186	0.754	
1/4—0.250	0.253	0.244	0.429	0.143	0.079	0.213	0.858	
9/32—0.281	0.285	0.273	0.482	0.161	0.088	0.239	0.963	
5/16—0.313	0.317	0.305	0.535	0.178	0.098	0.266	1.070	
11/32—0.344	0.348	0.336	0.589	0.196	0.108	0.292	1.176	
3/8—0.375	0.380	0.365	0.644	0.215	0.118	0.319	1.286	
7/16—0.438	0.443	0.428	0.750	0.250	0.137	0.372	1.500	

All dimensions given in inches.

Approximate Proportions: $D = 1.720 \times A$; $H = 0.570 \times A$; $r_1 = 0.314 \times A$; $r_2 = 0.850 \times A$; $r_3 = 3.430 \times A$.

Fillets. Rivets other than the countersunk type are acceptable with fillets under the head up to 1/32 in. radii.

Tolerances. The tolerances on the nominal diameters of the shanks shall be those given in the following table:

Diameters of shanks (inclusive)	Tolerances	
	Plus	Minus
3/32— 5/32	0.002	0.004
3/16— 1/4	0.003	0.006
9/32—11/32	0.004	0.008
3/8 — 7/16	0.005	0.010

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

Finish. The finished rivets shall be free from injurious defects.

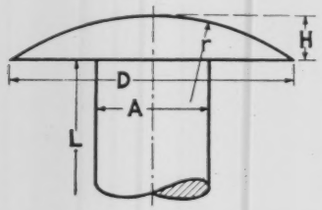


TABLE 5 TRUSS-HEAD RIVETS—SEE SKETCH ABOVE

A Diameter of Shank Nominal	A Diameter of Shank Maximum	A Diameter of Shank Minimum	D Diameter of head	H Height of head	r Radius of top	L Length under head
3/32—0.094	0.096	0.090	0.238	0.032	0.239	Ordered length under head to end
1/8 —0.125	0.127	0.121	0.313	0.042	0.314	
5/32—0.156	0.158	0.152	0.390	0.052	0.392	
3/16—0.188	0.191	0.182	0.468	0.062	0.470	
7/32—0.219	0.222	0.213	0.550	0.073	0.555	
1/4 —0.250	0.253	0.244	0.625	0.083	0.628	
9/32—0.281	0.285	0.273	0.703	0.094	0.706	
5/16—0.313	0.317	0.305	0.780	0.104	0.784	
11/32—0.344	0.348	0.336	0.858	0.114	0.862	
3/8 —0.375	0.380	0.365	0.938	0.125	0.942	
7/16—0.438	0.443	0.428	1.093	0.146	1.098	

All dimensions given in inches.

Approximate Proportions: $D = 2.500 \times A$; $H = 0.330 \times A$; $r = 2.512 \times A$.

Fillets. Rivets, other than the countersunk type, are acceptable with fillets under the head up to 1/32 in. radii.

Tolerances. The tolerances on the nominal diameters of the shanks shall be those given in the following table:

Diameters of shanks (inclusive)	Tolerances	
	Plus	Minus
3/32— 5/32	0.002	0.004
3/16— 1/4	0.003	0.006
9/32—11/32	0.004	0.008
3/8 — 7/16	0.005	0.010

No standard tolerances for the dimensions of the heads are contemplated. For work where restrictions as to head tolerances are necessary, these shall be considered special.

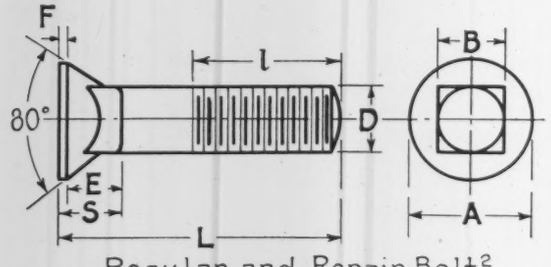
Finish. The finished rivets shall be free from injurious defects.

Plow Bolts

PLOW BOLTS NO. 3—BOLT AND THREAD LENGTHS, ETC.

Nominal diameter of bolt	5/16	3/8	7/16	1/2	9/16	5/8	3/4	
Threads per inch	18	16	14	13	12	11	10	Length tolerance
Length of bolt (L)	Minimum length of thread[1] (l)							(+ or −)
3/4	T to H	T to H	T to H	....	....	....	....	1/32
7/8	T to H	T to H	T to H	T to H	....	....	....	1/32
1	T to H	T to H	T to H	T to H	....	....	....	1/32
1 1/8	11/16	3/4	5/8	T to H	....	....	....	1/32
1 1/4	3/4	3/4	5/8	T to H	T to H	T to H	....	1/32
1 3/8	7/8	3/4	3/4	3/4	T to H	T to H	....	1/32
1 1/2	1	7/8	7/8	7/8	3/4	7/8	....	1/32
1 3/4	7/8	7/8	7/8	7/8	7/8	1 1/8	....	1/16
2	7/8	7/8	7/8	7/8	1 1/8	1 1/8	....	1/16
2 1/4	....	7/8	1	1	1 1/8	1 1/4	1 1/4	1/16
2 1/2	....	1	1	1	1 1/4	1 1/4	1 1/4	1/16
2 3/4	....	1	1	1	1 1/4	1 1/4	1 1/4	1/16
3	....	1	1	1	1 1/4	1 1/4	1 1/4	1/16

All dimensions given in inches.
"T to H" means "threaded to head."
[1] These threads are to conform to the American Standard B 1a-1924.



Regular and Repair Bolt[2]

SKETCH TO ACCOMPANY TABLE FOR PLOW BOLT NO. 3

Plow Bolt No. 3—Round Countersunk, Short Square

REGULAR BOLT

D Nominal diameter	Threads per inch	A Head diameter Minimum	A Head diameter Tolerance (+)	B Square neck[4] Maximum	B Square neck[4] Tolerance (−)	Included angle of head[1] (deg.)	S Minimum	F Feed thickness, Maximum	E Minimum
5/16	18	0.562 (9/16)	0.015	0.312	0.012	80	0.243	0.025	0.218
3/8	16	0.656 (21/32)	0.015	0.375	0.012	80	0.281	0.031	0.250
7/16	14	0.765 (49/64)	0.015	0.437	0.012	80	0.328	0.036	0.292
1/2	13	0.875 (7/8)	0.015	0.500	0.015	80	0.375	0.042	0.333
9/16	12	0.968 (31/32)	0.031	0.562	0.015	80	0.416	0.045	0.371
5/8	11	1.062 (1 1/16)	0.031	0.625	0.015	80	0.456	0.050	0.406
3/4	10	1.219 (1 7/32)	0.031	0.750	0.015	80	0.491	0.050	0.441

REPAIR BOLT[2]

D Nominal diameter	Threads per inch	a Head diameter[3] Minimum	a Head diameter[3] Tolerance (+)	b Square neck Maximum	b Square neck Tolerance (−)	Included angle of head,[1] (deg.)	s Minimum	f Feed thickness, Maximum	e Minimum
5/16	18	0.516 (33/64)	0.015	0.312	0.012	80	0.212	0.020	0.192
3/8	16	0.609 (39/64)	0.015	0.375	0.012	80	0.247	0.025	0.222
7/16	14	0.719 (23/32)	0.015	0.437	0.012	80	0.294	0.030	0.264
1/2	13	0.828 (53/64)	0.015	0.500	0.015	80	0.340	0.035	0.305
9/16	12	0.922 (59/64)	0.031	0.562	0.015	80	0.383	0.040	0.343
5/8	11	1.016 (1 1/64)	0.031	0.625	0.015	80	0.418	0.040	0.378
3/4	10	1.172 (1 11/64)	0.031	0.750	0.015	80	0.453	0.040	0.413

All dimensions given in inches.
[1] The tolerance on the included angle shall be plus 2 deg.
[2] The reference letters corresponding to the dimensions of the repair bolts are identical with those of the regular bolts but are printed in lower-case type.
[3] To distinguish the repair bolts from regular bolts of the same type, a large "R" shall be stamped on the top of its head or this top surface shall be painted red.
[4] These dimensions for cold-upset wire.

Plow Bolt No. 4—Square Head, Countersunk

(See sketch at top of next column)

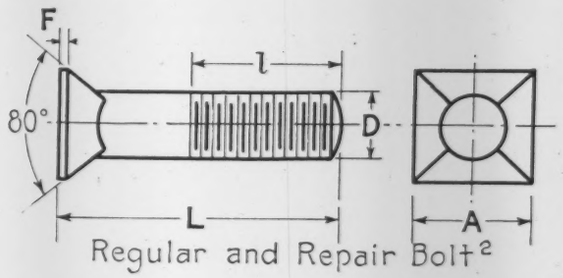
REGULAR BOLT

D Nominal diameter	Threads per inch	A Head Diameter Minimum	A Head Diameter Tolerance (+)	F Feed thickness max.	Included angle of head[1] (deg.)
5/16	18	0.562 (9/16)	0.015 (1/64)	0.025	80
3/8	16	0.687 (11/16)	0.015 (1/64)	0.031	80
7/16	14	0.750 (3/4)	0.015 (1/64)	0.036	80
1/2	13	0.812 (13/16)	0.015 (1/64)	0.042	80
9/16	12	0.937 (15/16)	0.031 (1/32)	0.045	80
5/8	11	1.000 (1)	0.031 (1/32)	0.050	80
3/4	10	1.125 (1 1/8)	0.031 (1/32)	0.050	80
7/8	9	1.312 (1 5/16)	0.031 (1/32)	0.050	80
1	8	1.500 (1 1/2)	0.031 (1/32)	0.050	80

REPAIR BOLT[2]

D Nominal diameter	Threads per inch	a Head diameter[3] Minimum	a Head diameter[3] Tolerance (+)	f Feed thickness, max.	Included angle of head[1] (deg.)
5/16	18	0.515 (33/64)	0.015 (1/64)	0.020	80
3/8	16	0.640 (41/64)	0.015 (1/64)	0.025	80
7/16	14	0.703 (45/64)	0.015 (1/64)	0.030	80
1/2	13	0.765 (49/64)	0.015 (1/64)	0.035	80
9/16	12	0.890 (57/64)	0.031 (1/32)	0.040	80
5/8	11	0.953 (61/64)	0.031 (1/32)	0.040	80
3/4	10	1.078 (1 5/64)	0.031 (1/32)	0.040	80
7/8	9	1.265 (1 17/64)	0.031 (1/32)	0.040	80
1	8	1.453 (1 29/64)	0.031 (1/32)	0.040	80

All dimensions given in inches.
[1] The tolerance on the included angle shall be plus 2 deg.
[2] The reference letters corresponding to the dimensions of the repair bolts are identical with those of the regular bolts but are printed in lower-case type.
[3] To distinguish the repair bolts from regular bolts of the same type, a large "R" shall be stamped on the top of its head or this top surface shall be painted red.



PLOW BOLT NO. 6—BOLT AND THREAD LENGTHS, ETC.

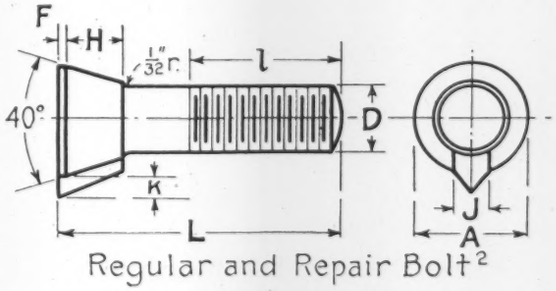
Nominal diameter of bolt		3/8	7/16	1/2	
Threads per inch		16	14	13	
Length bolt (L)	Minimum length of thread[1] (l)				Length tolerance (+ or −)
3/4		T to H	T to H	T to H	1/32
7/8		T to H	T to H	T to H	1/32
1		T to H	T to H	T to H	1/32
1 1/8		T to H	T to H	T to H	1/32
1 1/4		T to H	T to H	T to H	1/32
1 3/8		T to H	T to H	T to H	1/32
1 1/2		15/16	7/8	7/8	1/32
1 3/4		7/8	7/8	7/8	1/16
2		7/8	7/8	7/8	1/16
2 1/4		7/8	1	1	1/16
2 1/2		7/8	1	1	1/16
2 3/4		1	1	1	1/16
3		1	1	1	1/16

All dimensions given in inches.
"T to H" means "threaded to head."
[1] These threads are to conform to the American Standard, B 1a-1924.

PLOW BOLT NO. 4—BOLT AND THREAD LENGTHS, ETC.

Nominal diameter		5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	
Threads per inch		18	16	14	13	12	11	10	9	8	
Length of bolt (L)	Minimum length of thread[1] (l)										Length Tolerance (+ or −)
3/4		T to H	T to H	T to H	....	....	....	....	....	....	1/32
7/8		T to H	T to H	T to H	T to H	....	....	....	....	....	1/32
1		T to H	T to H	T to H	T to H	....	....	....	....	....	1/32
1 1/8		11/16	3/4	5/8	T to H	....	....	....	....	....	1/32
1 1/4		3/4	7/8	5/8	T to H	T to H	T to H	....	....	....	1/32
1 3/8		....	3/4	3/4	3/4	T to H	T to H	....	....	....	1/32
1 1/2		....	7/8	7/8	7/8	7/8	7/8	....	....	....	1/32
1 3/4		....	7/8	7/8	7/8	7/8	1	....	....	....	1/16
2		....	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	....	....	1/16
2 1/4		....	7/8	1	1	1 1/8	1 1/4	1 1/4	1 1/4	1 1/4	1/16
2 1/2		....	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1/16
2 3/4		....	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1/16
3		....	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1/16

All dimensions given in inches.
"T to H" means "threaded to head."
[1] These threads are to conform to the American Standard, B 1a-1924.



SKETCH TO ACCOMPANY TABLE ON PLOW BOLT NO. 6

Plow Bolt No. 6—Heavy Key, Round Head, Countersunk

REGULAR BOLT									REPAIR BOLT[2]		
D Nominal diameter	Threads per inch	A Head diameter Minimum	A Head diameter Tolerance (+)	F Feed thickness, max.	Included angle of head,[1] (deg.)	H Height of head, max.	J Key width, max.	K Key proj., max.	a Head diam.,[3] max.	f Feed thickness, max.	h Height of head, max.
3/8	16	0.725	0.015	0.050	40	0.310	0.156	0.100	0.708	0.025	0.286
7/16	14	0.796	0.015	0.050	40	0.367	0.172	0.100	0.770	0.030	0.339
1/2	13	0.867	0.015	0.050	40	0.430	0.188	0.100	0.836	0.035	0.402

All dimensions given in inches.
[1] The tolerance on the included angle shall be plus 2 deg. [2] The reference letters corresponding to the dimensions of the repair bolts are identical with those of the regular bolts but are printed in lower-case type. [3] To distinguish the repair bolts from regular bolts of the same type, a large "R" shall be stamped on the top of its head or this top surface shall be painted red.

Plow Bolt No. 7—Reverse Key, Round Head, Countersunk

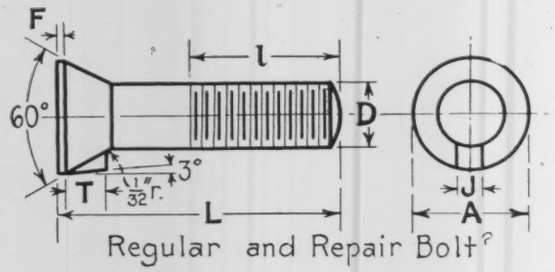
REGULAR BOLT

D Nominal diameter	Threads per inch	*A* Head diameter Minimum	*A* Head diameter Tolerance (+)	*F* Feed thickness, max.	Included angle of head,[1] (deg.)	*J* Key width Maximum	*J* Key width Tolerance (−)	*T* Key length Minimum	*T* Key length Tolerance (+)
5/16	18	0.562 (9/16)	0.015	0.025	60	0.156	0.005	0.185	0.015
3/8	16	0.625 (5/8)	0.015	0.031	60	0.156	0.005	0.187	0.015
7/16	14	0.734 (47/64)	0.015	0.036	60	0.156	0.005	0.227	0.015
1/2	13	0.843 (27/32)	0.015	0.042	60	0.156	0.005	0.267	0.015
9/16	12	0.968 (31/32)	0.015	0.045	60	0.156	0.005	0.321	0.015
5/8	11	1.063 (1 1/16)	0.015	0.050	60	0.156	0.005	0.348	0.015
3/4	10	1.218 (1 7/32)	0.015	0.050	60	0.156	0.005	0.375	0.015

REPAIR BOLT[2]

D Nominal diameter	Threads per inch	*a* Head diameter[3] Minimum	*a* Head diameter[3] Tolerance (+)	*f* Feed thickness, max.	Included angle of head[1] (deg.)	*j* Key width Maximum	*j* Key width Tolerance (−)	*t* Key length Minimum	*t* Key length Tolerance (+)
5/16	18	0.531 (17/32)	0.015	0.020	60	0.156	0.005	0.158	0.015
3/8	16	0.593 (19/32)	0.015	0.025	60	0.156	0.005	0.158	0.015
7/16	14	0.703 (45/64)	0.015	0.030	60	0.156	0.005	0.199	0.015
1/2	13	0.812 (13/16)	0.015	0.035	60	0.156	0.005	0.239	0.015
9/16	12	0.937 (15/16)	0.015	0.040	60	0.156	0.005	0.293	0.015
5/8	11	1.031 (1 1/32)	0.015	0.040	60	0.156	0.005	0.321	0.015
3/4	10	1.187 (1 3/16)	0.015	0.040	60	0.156	0.005	0.347	0.015

All dimensions given in inches.
[1] The tolerance on the included angle shall be plus 2 deg.
[2] The reference letters corresponding to the dimensions of the repair bolts are identical with those of the regular bolts but are printed in lower-case type.
[3] To distinguish the repair bolts from regular bolts of the same type, a large "R" shall be stamped on the top of its head or this top surface shall be painted red.



SKETCH TO ACCOMPANY TABLE ON PLOW BOLT NO. 7

PLOW BOLT NO. 7—BOLT AND THREAD LENGTHS, ETC.

Nominal diameter of bolt	5/16	3/8	7/16	1/2	9/16	5/8	3/4	
Threads per inch	18	16	14	13	12	11	10	Length tolerance (+ or −)
Length of bolt (*L*)	Minimum length of thread[1] (*l*)							
3/4	T to H	T to H	T to H	....	....	....	....	1/32
7/8	T to H	T to H	T to H	....	....	....	....	1/32
1	T to H	T to H	T to H	T to H	....	....	....	1/32
1 1/8	11/16	3/4	5/8	T to H	....	....	....	1/32
1 1/4	3/4	3/4	5/8	T to H	T to H	T to H	....	1/32
1 3/8	....	3/4	3/4	3/4	T to H	T to H	....	1/32
1 1/2	....	7/8	7/8	7/8	7/8	7/8	....	1/32
1 3/4	....	7/8	7/8	7/8	7/8	1	....	1/16
2	....	7/8	7/8	7/8	1 1/8	1 1/8	1 1/8	1/16
2 1/4	....	7/8	1	1	1 1/8	1 1/4	1 1/4	1/16
2 1/2	....	1	1	1	1 1/4	1 1/4	1 1/4	1/16
2 3/4	....	1	1	1	1 1/4	1 1/4	1 1/4	1/16
3	....	1	1	1	1 1/4	1 1/4	1 1/4	1/16

All dimensions given in inches.
"T to H" means "threaded to head."
[1] These threads are to conform to the American Standard, B 1a-1924.

Engineering and Industrial Standardization

Cranes, Derricks, and Hoists New Sectional Committee to Develop Safety Code

THE American Society of Mechanical Engineers as sponsor for this project called the members of the new Sectional Committee together for organization on November 4. Invitations to appoint official representatives had been sent in March to 50 national societies and trade associations. At the same time approximately 300 firms which manufacture and use this type of equipment were notified that the development of this safety code was under way.

During the meeting it was stated that probably the first work in this field was that of the A.S.M.E. Committee on the Protection of Industrial Workers. In December, 1916, this Committee presented a Code of Safety Standards for Cranes which was adopted by that Society. Since that time the Safety Code Correlating Committee and the American Engineering Standards Committee have given considerable thought to this project, and they have been encouraged by the International Association of Industrial Accident Boards and Commissions, the American Museum of Safety, and the Locomotive Crane Manufacturers Association.

The Sectional Committee on a Safety Code for Cranes, Derricks, and Hoists recognizes the fact that some states have already developed and published regulations covering the manufacture and use of these machines. It is also informed concerning the work of the Committee of the Association of Iron and Steel Electrical Engineers and the Sectional Committee on a Safety Code for Construction Work sponsored by the National Safety Council. It hopes, however, to develop a comprehensive national code on this subject which may in time be adopted in whole or in part by the industrial boards and commissions of the several states.

The Committee decided to organize six sub-committees on the following divisions of the subject: (1) Overhead and Gantry Cranes, (2) Locomotive and Tractor Cranes, (3) Hoists, (4) Derricks, (5) Slings, Chains, and Hooks, (6) Wire Rope and Attachments, Sheaves, and Pulleys.

J. C. Wheat, chief engineer of the Industrial Works, Bay City, Mich., was elected temporary chairman, and Benjamin F. Tillson, temporary secretary. These two gentlemen together with Messrs. J. F. Conner, A. H. McDougall, O. J. Smith, and R. H. White constitute the Executive Committee, which was given broad powers concerning personnel of sub-committees, scope of the project, and the subdivision of the scope among the six sub-committees.

Among those present were the following representatives of the organizations named:

A. H. MCDOUGALL, American Foundrymen's Association
M. F. CHRISTENSEN, American Warehousemen's Association
H. H. VERNON, American Institute of Electrical Engineers
J. H. STREET, The American Society of Mechanical Engineers
R. H. WHITE, The American Society of Mechanical Engineers

B. F. TILLSON, American Institute of Mining and Metallurgical Engineers
H. J. SOLON, Associated General Contractoss of America
COL. D. H. SAWYER, Associated General Contractors of America
R. W. OWENS, Electric Power Club
C. B. BRADISH, Electric Power Club
DR. L. W. CHANEY, International Association of Industrial Accident Boards and Commissions
J. C. WHEAT, Locomotive Crane Manufacturers Association
F. M. BULLEN, National Bureau of Casualty and Surety Underwriters
J. L. DEINISH, National Bureau of Casualty and Surety Underwriters
K. M. IRWIN, National Electric Light Association
MAJOR PHILIP R. FAYMONVILLE, United States War Department
J. S. KENNEDY, Consolidated Gas Company
L. F. MITTEN, Vulcan Iron Works
J. W. POLLOCK, Baldwin Locomotive Works
DR. P. G. AGNEW, Secretary, American Engineering Standards Committee
F. J. SCHLINK, Assistant Secretary, American Engineering Standards Committee
CARL B. AUEL, A.S.M.E. Safety Committee
COL. JOHN PRICE JACKSON, Chairman, A.S.M.E. Safety Committee
CLIFFORD B. LEPAGE, Assistant Secretary, The American Society of Mechanical Engineers.

Three New American Standards to Be Issued Soon

SPUR-GEAR TOOTH FORM

AT ITS meeting in Briarcliff, N. Y., in October the American Gear Manufacturers Association approved and adopted the proposed American Standard for the tooth form of the 14½-degree composite system and the tooth form of the 20-degree stub involute system of spur gears. This standard was presented for discussion at the Spring Meeting of the A.S.M.E. in San Francisco, Cal., in June, 1926, and was printed in the November, 1926, issue of MECHANICAL ENGINEERING. It was later approved and adopted by the Council as a standard practice of the Society.

It will be recalled that this is the first proposal for an American Standard to be presented by the Sectional Committee on the Standardization of Gears to the American Gear Manufacturers Association and The American Society of Mechanical Engineers which are its joint sponsors. This proposed standard is now before the American Engineering Standards Committee with the recommendation of the sponsors that it be approved and designated as "American Standard."

WRENCH-HEAD BOLTS AND NUTS

After many redrafts and thorough revisions at the hands of Sub-Committee No. 2 on Wrench-Head Bolts and Nuts, this report containing proposed Tentative American Standards for (1) Rough and Semi-Finished Square and Hexagonal Regular Bolt Heads, (2) Finished Square and Hexagonal Bolt Heads, (3) Finished Hexagonal Cap-Screw Heads, (4) Set-Screw Heads, (5) Rough and Semi-Finished Square and Hexagonal Regular Nuts, (6) Finished Square and Hexagonal Regular Nuts, (7) Finished and Semi-Finished Jam Nuts, (8) Hexagonal Light Nuts, (9) Hexagonal and Square Machine-Screw Nuts and Stove-Bolt Nuts, (10) Castellated Nuts, and (11) Open-End Wrench Openings, has recently received the approval of the sponsor organizations and has been presented to the American Engineering Standards Committee with the recommendation that it be approved and designated a Tentative American Standard. This standard was printed in the May, 1926, issue of MECHANICAL ENGINEERING and the May, 1926, issue of the *Journal of the Society of Automotive Engineers*.

In 1922 the Society of Automotive Engineers and The American Society of Mechanical Engineers agreed to organize and sponsor a Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions. This Committee held its first meeting in March, 1922, and assigned the various parts of the project to the following eight Sub-Committees: No. 1 on Large and Small Rivets; No. 2 on Wrench-Head Bolts and Nuts; No. 3 on Slotted-Head Proportions; No. 4 on Track Bolts and Nuts; No. 5 on Carriage Bolts; No. 6 on Special Bolts and Nuts for Agricultural Equipments; No. 7 on Body Dimensions and Material; and No. 8 on Nomenclature. Proposed standards as the results of the work of these Sub-Committees may be expected in the very near future. In fact, the reports of the following Sub-Committees are now before the sponsors for approval:

Sub-Committee No. 1, Tentative American Standard for Small Rivets, Tentative American Standard for Tinner's Coopers', and Belt Rivets
Sub-Committee No. 5, Tentative American Standard for Round Unslotted-Head Bolts
Sub-Committee No. 6, Tentative American Standard for Plow Bolts.

STEEL FLANGES AND FLANGED FITTINGS

With the submission of the proposed Tentative American Standards for steel flanges and flanged fittings to withstand working steam pressures of 250, 400, 600, 900, and 1350 lb. per sq. in. and 750 deg. fahr. a new record in national standardization will have been made.

Rarely if ever before in the mechanical industries has a series of standards been created in advance of common practice. Three years ago when Sub-Committee No. 3 began its work a few steam power plants were in operation at 350 and 400 lb. pressure, and plans were being developed for one or two 600-lb. stations. Except for the two lower pressures the field was therefore entirely clear, and the Sub-Committee mapped out a series of standard pressures up to the critical point. They bear a geometrical ratio to each other and are as follows: 250, 400, 600, 900, 1350, 2000, and 3200 lb.

Proposed Tentative American Standards for Steel Flanges and Flanged Fittings covering the first five of these pressures will be transmitted to the American Engineering Standards Committee for approval within a week or two. They were approved in final form by the Sectional Committee at its meeting on October 21, 1926, and have since received the approval of the Heating and Piping Contractors National Association, and the Manufacturers Standardization Society of the Valve and Fittings Industry, two of the sponsor organizations. The Council of The American Society of Mechanical Engineers is now voting on these standards. Our readers will find an abstract of this report in the August, 1926, issue of MECHANICAL ENGINEERING.

Safety Exhibit at Annual Meeting

THE A.S.M.E. Safety Committee has planned for some time to present to the membership of the Society some concrete evidence of the progress which has been made in guarding machines at the point of operation. Principally through the activities of Carl B. Auel, functioning as a Sub-Committee on the Exhibit, a considerable collection of easily portable devices have been loaned to the Committee and are being set up for view by those who attend the 1926 Annual Meeting.

In the north corridors on the third and fourth floors of the Engineering Societies Building will be found this interesting exhibit of approved mechanical safety devices which have been loaned for the week of the meeting.

All of these devices have been developed by the firms exhibiting them with the purpose of building guards which would meet the requirements of the various safety codes formulated and approved under the procedure of the American Engineering Standards Committee. The greater number of devices shown comply with the provisions of the Safety Code for Mechanical Power Transmission Apparatus and the Safety Code for Punch Presses, but the exhibit contains many other guards and safety devices referred to in the other codes.

Corrections

IN the paper by Archibald Black in the November issue on Civil Aviation in the United States, it should have been stated that Figs. 1 and 2 and Table 1 had been copyrighted by the author.

In the same issue, on page 1179, E. J. Kates' position should have read "consulting engineer," New York City. Mr. Kates, is no longer associated with the De La Vergne Machine Co.

On p. 1157 in the first sentence of the first paragraph, the date should have read June, 1921, instead of June, 1926.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

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"Mathematics Is a Language"[1]

THERE is an ever-increasing number of engineers who do not hesitate to use mathematics in articles which they write for the engineering press. MECHANICAL ENGINEERING and the Transactions of the A.S.M.E. bear witness to this, and readers of these publications find themselves more and more at a disadvantage if the language of mathematics is unknown or unfamiliar to them. It would be well for young engineers to recognize this unmistakable trend of the literature in which they should find interest and profit, and correct any deficiency which their education or lazy-mindedness may have caused.

The beauty of the language of mathematics lies in the fact that it is precise and concise—it admits of no double interpretations such as confound lawyers in the statements of legal documents, and its conclusions are logical and consistent. Poets might clothe the truths of mathematical deductions with a fabric of beautiful words whose music would beguile the ear or arrest the attention, but invariably the truths themselves would suffer by being less concretely, even more subtly, expressed. Thus a mathematician might express the First Law of Thermodynamics by writing $dq = du + Apdv$, while Keats, voicing an analogous truth, says, "I change, but I cannot die." One would not translate the thoughts of the poets into the language of mathematics, but neither should one seek to substitute the expressions of poets for the more suitable equations of mathematics. It is as unsatisfactory to express the specific heat of superheated steam in the King's English as it is to describe a sunset in terms of wave lengths.

But there are dangers in the use of mathematics in engineering papers which are destined for a numerous and varied audience, and there are obligations on those who use this method for such readers. Symbols and the initial statements of the mathematical developments cannot be too clearly interpreted to the reader. The writer should recognize that while to him the symbol q in the equation of the previous paragraph invariably represents energy as heat, to another it may suggest nothing at all, or possibly cubic feet of water. The symbols cannot be too clearly defined. It would also seem desirable, inasmuch as the reader is probably unfamiliar with the system of symbols and is quite as perplexed trying to remember them as he is trying to grasp the idea represented by the equation into which the author has so cleverly juggled them, to have the author present his idea qualitatively in words as well as quantitatively in symbols. Thus if he were to say that the gain or loss of heat will result in a change of intrinsic energy and external work, to return to the equation of the previous paragraph, the average reader would grant the probable truth of the statement and connect the quantitative differential relationship with the qualitative explanation of it. Whatever mathematical development of this equation may follow will probably have a physical interpretation if the mathematics is correct, and if the mathematician is clever enough to discover what it is.

The common difficulty with these mathematical papers is not that we have not studied mathematics; it is not that we are too unintelligent to follow the author's reasoning; it is that we do not know how to use mathematics as a tool and we are too lazy to puzzle out what the author has proved. The average eye trails easily across the indented portion of the page in which the Greek alphabet and mathematical symbols say in a few lines what a dozen pages could not say so concisely or so accurately, and tries to pick up the thread of the argument from a more leisurely text. "A man learns to use the calculus as he learns to use a chisel or a file on actual concrete bits of work," writes John Perry. Engineers cannot get too extensive a training in the use of these tools.

There lies in wait for users of the mathematical method the very silly danger of affectation and pedantry, of needless obscurity of expression. This brings discredit on the method and on those who abuse it. Here again the choice of the proper tool for the job to be done must be kept in mind. Too many papers are written, not for the great body of readers who will profit from them, but for a small group of critics in related fields of research with whom the author fears to lose caste if he fails to use the jargon of the high priests. Engineering has always been refreshingly free from this because its literature and methods have come from practical men free from scholastic affectation. It would be unfortunate, for instance, to have the rich Anglo-Saxon terminology Latinized, as has happened in many of the newer sciences.

Mathematics will probably become more and more the language of engineers, especially of those who are in the field of research and of those engaged in problems which are more cheaply experimented with on paper than in costly concrete form. We do not order a dozen bridge spans and then use the one which does not break under the strain. Engineers will gain more than the value of the time required for the mastery of the fundamentals of mathematics. They will equip themselves with a powerful tool and an adequate language.

[1] A statement attributed to Willard Gibbs.

The Conference Table

PROGRESS no matter in what line of endeavor it may be, always results from the meeting of minds interested in similar problems. The director of an industrial establishment finds it advantageous when confronted by a puzzling situation to sit at the table with his department heads and freely discuss with them the various angles of the problem. He encourages the suggestion of possible solutions, which are then thoroughly analyzed in open discussion and the merits of each noted. The physician, regardless of how well he may be informed on the latest and best practice in his profession, knows that a "consultation" may bring to light some little, unthought-of, but very important, bit of information which may prove instrumental in the saving of a life. Progress in the engineering field has been greatly aided by the willingness of members of the profession to discuss their problems in open meeting.

Many engineers, however, are not in positions enabling them to call meetings at will to compare notes and exhaustively discuss possible solutions of their problems. While it is true that an individual in this class may have access to the files of his engineering society, too often there is nothing immediately available which is applicable to the problem at hand. On such occasions, no doubt, he has felt that his society would be of vastly more value to him if there were some means, easily accessible, whereby he might submit the problem for open discussion.

It is just this condition which prompted the creation of the Conference Table section of MECHANICAL ENGINEERING. The November, 1926, issue marked the inauguration of the department

and readers will have observed that the first series of questions and answers involved six Professional Divisions of the Society. Each Division, organized through common interest in a particular phase of mechanical engineering, has been enlisted in this work, and the representatives of all are interested in placing the latest and best information at the disposal of the department.

Just a word as to the manner in which the work is carried on. Questions as received are classified according to Professional Divisions. Each group of questions is typed on a sheet, copies of which are placed in the hands of the special representatives already referred to. These men, in turn, distribute them among members whom they know to be well qualified to handle the problems presented. The answers are published but the final analysis is left to the questioner, who may compare notes at his leisure and draw conclusions as if he had actually presided over a conference in his office. He has this advantage, however. In a conference of his immediate associates, even in an establishment of considerable size, he has the benefit of experience in but a few plants at the best under few conditions. In the Conference Table, on the other hand, he may have the benefit of the experiences of engineers in all corners of the country: men who are familiar with manufacturing and engineering methods of which he and his associates have little or no knowledge.

There is another point worthy of attention, and that is man's inherent timidity in the matter of asking questions in meetings or in print. There is always the fancied possibility that some one in the audience or among the readers may think the inquiry a foolish one. This same individual would not hesitate in a conference with his fellow-workers, however, because he knows pretty well the mental caliber of those about him. Let the timid ones be assured that they are even safer from the judgment of others in the Conference Table, for no questions are signed. The names of the informants, however, do appear, for it is very desirable that the reader know with what degree of confidence the answers may be accepted, and also for convenience of reference in case of further discussion.

While these remarks are directed primarily at the seeker of information, they may well be pondered upon by the possessor of facts of interest. Just as it is profitable to comment on the remarks of others in the office conference of plant department heads or in the convention hall, so is it well worth the effort and time required to study the published answers and, where possible, add a thought or contribute facts.

Management Week

MANAGEMENT WEEK, October 25 through 30, 1926, gave American industry and engineering an opportunity to appraise the progress accomplished in waste elimination during the last five years. One hundred and thirty meetings were held in 117 industrial centers throughout the country, at which various phases of the main topic, "Progress in Waste Elimination," were discussed. Complete reports are at hand from only a third of the local committees, but they already indicate that the 1926 event outstripped the five previous weeks in attendance, enthusiasm, and the wholehearted coöperation of many assisting organizations. The enthusiasm of the Pittsburgh Committee is especially noteworthy, for, in addition to several splendid meetings held throughout the week, a series of pertinent radio talks were broadcast over KDKA.

Management Week was started in 1922 by the coöperative action of the American Institute of Accountants, the American Management Association, The American Society of Mechanical Engineers, and the Taylor Society.

In the 1926 Management Week, in addition to the five organizing societies a large number of other commercial and civic organizations gave wholehearted support to the movement. The National Committee consisted of W. H. Leffingwell, Chairman and Treasurer, representing the Taylor Society; Wallace Clark, Society of Industrial Engineers; John Price Jackson, American Management Association; Park T. Sowden, The American Society of Mechanical Engineers; Cecil S. Ashdown, American Institute of Accountants; and R. M. Hudson, Chief of Division of Simplified Practice, U. S. Department of Commerce, Secretary.

A Letter from President Kimball of the A.E.C. on Judges' Salaries

AMERICAN ENGINEERING COUNCIL
26 Jackson Place, Washington, D. C.
November 8, 1926

To every member of the A.S.M.E.:

The time has arrived for final action on behalf of this important measure. The bill has passed the Senate, and is definitely set for a vote in the House of Representatives, December 9th. It is believed the Bill can be passed if sufficiently vigorous support is given to it, and every man and corporation does his or its part. It must be passed if the quality of the Federal Judiciary is to be maintained.

United States District Judges are now receiving only $7,500 and the Circuit Judges, $8,500 per annum. The Chief Justice of the Supreme Court of the United States receives only $15,500 and the Associate Justices only $15,000 per annum. The salaries of the United States Circuit and District Judges are much below those paid in many states, and are only one-third of the amount paid to the corresponding Judges in the State of New York.

The United States Judges can live only by the greatest economy on their present salaries, and it is actually impossible for them to send their children to college on these salaries. They are practically shut off, by their position, from all other ways of earning money, except from simple investments, savings for which it is impossible to accumulate. A considerable number of the Judges have resigned in recent years and months because of this situation. All of those in the larger cities feel unjustly treated, and some of them feel bitter. Not a few of the Judges will resign if the Bill does not pass on December 9th.

The Bill to be voted upon increases their salaries to $10,000 for the District Judges and $12,000 for the Circuit Judges, and $20,500 for the Chief Justice of the United States and $20,000 for the Associate Justices, and provides for corresponding increases for other Federal Judges.

American Engineering Council and its constituent Engineering Societies have been vigorously supporting the Bill in the Senate and House of Representatives, and have been represented before a number of Congressional Committee Meetings.

The passage of this Bill deeply concerns not only every American Engineer, but the welfare of our country. It is grossly unjust to have invited capable lawyers to give up profitable practices and take appointments as United States Circuit or District Judges in days past, when the salaries afforded a comfortable and dignified living, and then, when the cost of living goes up, not to increase the salaries at least proportionately. This condition is not only unjust but it is poor business; because the Judges cannot do their best work when their minds are harassed with the almost impossibility of making both ends meet, and living with the dignity which their position requires. American Engineering Council is certain that the members of the constituent Engineering Societies, having undertaken to see this legislation safely through, will give hearty response to this call for appeal to the members of Congress.

Please write to your member of Congress in the early days of December urging him to be present December 9th, when the Graham Bill, H. R. 10,544 will be voted upon, and to give the Bill his hearty support.

If the Bill should not pass December 9th, the leaders of Congress predict that it will be many years before another attempt will have any chance for success.

American Engineering Council, and its constituent societies, was one of the three great factors in passing the Patent Office Relief Bill. This Judges Salaries Bill is of equal importance with the Patent Office Bill. We believe it can be passed, but only if every man will do his part. We hope and expect that the great majority of the Engineers will respond to this call for public service.

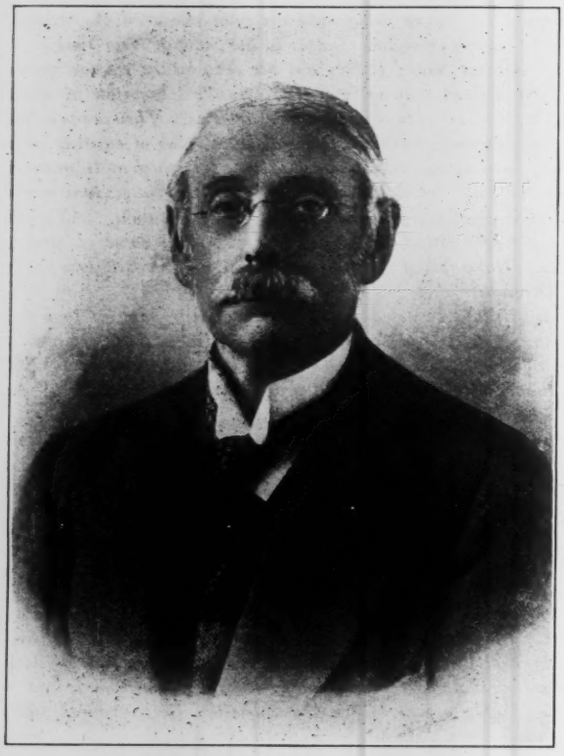
Very truly yours,
(Signed) DEXTER S. KIMBALL,
President,
American Engineering Council
(Signed) EDWIN J. PRINDLE,
Chairman, Patents Committee

Sir Charles Algernon Parsons Awarded Kelvin Medal

TO THE Honorable Sir Charles Algernon Parsons, Honorary Member of The American Society of Mechanical Engineers, has been awarded the Kelvin Gold Medal, which is conferred triennially as a mark of distinction on some person who has reached eminence as an engineer or investigator in the kind of work applicable to the advancement of engineering with which Lord Kelvin was especially identified. This medal is one of the most highly regarded trophies in the world of science.

Development of Steam Turbine

The commercial development of the steam turbine and its application to useful purposes on a comparatively large scale, one of the distinct achievements in steam engineering during the latter part of the nineteenth century, has become inseparately associated with the name of Sir Charles Algernon Parsons.



Sir Charles Algernon Parsons

In 1884 Sir Charles became a partner in the firm of Clarke, Chapman, Parsons & Co. The electrical industry at that time being the latest development of engineering, he conceived the idea that a high-speed, direct-coupled engine was required to drive the dynamo and that the steam turbine was the engine to do it.

His inventions include non-skid chains for automobile tire, an auxeto-gramophone in 1898, and the compound turbine known by his name, introduced about 1884, improved by a condenser in 1891, and adapted for maritime use on the *Turbinia* in 1897. About 1900 he invented a geared turbine.

He is the author of many publications and monographs on the steam turbine. He is a member of the Institution of Civil Engineers of Great Britain, the Institution of Mechanical Engineers, and numerous other scientific and engineering societies. He was made an Honorary Member of our Society in 1920.

Other Recipients

The medal was first awarded in 1920 when Dr. William Cawthorne Unwin, F. R. S., of London, was the recipient. In 1923 it was conferred upon Dr. Elihu Thomson, past-president of the American Institute of Electrical Engineers.

The committee which makes the award consists of the presidents of the principal engineering societies of Great Britain, who ask for suitable nominations from the leading engineering societies in all parts of the world.

Duplication in Research

AS AN IMPORTANT part of the program of the A.S.M.E. for the year, the Standing Committee on Research is giving attention to the stimulation of research in the mechanical engineering field.

One general problem under discussion by the Committee is the apparent duplication of research efforts in a number of fields. This duplication may seem unnecessary, and in some cases it actually is. In general, however, the substantiation of the results of one study by an entirely independent investigation is often needed if the results of either study are to have value. It gives satisfaction to a research worker to have his results corroborated by another investigator with an entirely different research procedure and under different conditions. The engineer who works with the results has greater confidence in them if they have confirmation. To hastily condemn apparent repetition is therefore unwise unless the results of the two researches are not available for comparison. Whether duplication of research effort is helpful or unnecessary can only be decided when the investigators working on similar problems are informed about each other's plans. A clearing house of information about research contemplated and in progress should therefore be of assistance. The Committee formerly sponsored such an activity, but due to lack of funds it was abandoned in 1922. It will be resumed during the coming calendar year.

The Modern Saw Doctor

WOODWORKING machines, like machine tools, have one main reason for being, and that is to deliver adequate power at the cutting points and to present the work to the tools in the most efficient way possible. No machine of either type can do more than its tools will stand, regardless of how powerful and fast it may be. Hence the tool is the heart of the machine.

This has long been recognized by engineers in the metal-working field, but perhaps not so long by woodworkers. However this may be, the wood industries are now not only recognizing the importance of the cutting tools but they are taking active steps to insure that knowledge of the design, the manufacture, the use, and the maintenance of scientific wood-cutting tools shall be more widely understood.

In recent issues of Mechanical Engineering papers have been published which tell of studies in the art of cutting wood, and now we learn that in England this progress has developed a new kind of a "doctor"—the "saw doctor." While "saw doctor" does not connote a university degree, it actually is coming to indicate that the man so designated has received some very special training in such an institution as the Saw Doctor's School of Instruction at Sheffield.

In this school mill workmen, and also many mill managers and owners, are learning the correct principles of the art of cutting wood. The course covers the subject of saws and other cutters from the choice of steel down to their final adjustment and operation. The operating men take this instruction in order to be able to properly handle modern woodworking machinery, while managers and owners of woodworking plants are seeking to become familiar with the best equipment and to know when their plants are operating to the highest efficiency.

This interesting development in England is something of a challenge, not only to the wood industries of America but to the metal-working industries as well. In spite of the rapid progress being made in this country in the working of both wood and metal, there is still much room for improvement as far as instruction in the basic principles of both these vital industrial arts is concerned.

Fifteenth Annual Safety Congress

THE six thousand or more delegates in attendance at the National Safety Council's annual convention held in Detroit, Mich., October 25 to 29, 1926, were unanimous in declaring it the most

successful ever held. Three hundred speakers participated in the 86 sessions with excellent papers and addresses covering the entire field of accident prevention.

President Charles B. Scott, in his opening address, outlined the purposes which prompted the creation of the Council, and emphasized the principle that progress in industrial development is essential, but it must not be made at the cost of the waste of lives and limbs. He also pointed out that the responsibility for awakening and maintaining an industrial and public interest in the conservation of life so needlessly sacrificed in our advancement is the chief responsibility and greatest task of the Safety Council.

The National Safety Council is the recipient of a provisional contribution of $177,500 from John D. Rockefeller, Jr. The field of public safety is almost limitless and the requirements are clearly apparent. The financing of this important work should gain impetus from the encouragement given to it by Mr. Rockefeller.

W. G. King, American Optical Company, New York, was elected as the new president of the National Safety Council.

E. W. Beck, Safety Supervisor of the United States Rubber Company, of New York, was elected chairman of the American Society of Safety Engineers, Engineering Section of the National Safety Council. This section comprises the technical group of the National Safety Council and as such has accomplished much constructive work during the past year through its research committees, code work, etc.

The Nation's Program of Conservation in Industry

THE Annual Report of the Secretary of Commerce presents a valuable outline of industrial conditions which has a direct bearing on the engineering problems of industry. Secretary Hoover devotes a large amount of space to the campaign for the elimination of waste in production and distribution which has had the wholehearted support of the Department. The objectives of this campaign have but one purpose—to maintain American standards of living for both workers and farmers, and to place production on a more stable footing by enlarging consumption and export markets through reduced production and distribution costs. Extracts from the various sections of the report appear below.

PROGRESS IN ELIMINATION OF WASTE

The term "elimination of waste" is subject to some objection as carrying the implication of individual or wilful waste. In the sense used in these discussions elimination of waste refers wholly to those wastes which can be eliminated solely by coöperative action in the community. It does not refer to any single producer, for in the matters here discussed he is individually helpless to effect the remedy. Nor does the elimination of such wastes imply any lessening of fair competition or any infringement of the restraint-of-trade laws. In fact, the most casual investigation of the work in progress will show that its accomplishment establishes more healthy competition. It protects and preserves the smaller units in the business world. Its results are an asset alike to worker, farmer, consumer, and business man.

It may be worth while repeating the major directions for national effort as they were outlined by the Department at the beginning of the undertaking five years ago:

1 Elimination of the waste imposed by inadequate railway transportation, by improved equipment and methods, and the establishment of better coöperation.

2 Vigorous utilization of our water resources for cheaper transportation of bulk commodities, flood control, reclamation, and power.

3 Enlarged electrification of the country for the saving of fuel and labor.

4 Reduction of the great waste of booms and slumps of the "business cycle" with their intermittent waves of unemployment and bankruptcy.

5 Reduction of seasonal variations in employment in construction and other industries.

6 Reduction of waste in manufacture and distribution through the establishment of standards of quality, simplification of grades, dimensions, and performance in non-style articles of commerce; through the reduction of unnecessary varieties; through more uniform business documents such as specifications, bills of lading, warehouse receipts, etc.

7 Development of pure and applied scientific research as the foundation of genuine labor-saving devices, better processes, and sounder methods.

8 Development of coöperative marketing and better terminal facilities for agricultural products in order to reduce the waste in agricultural distribution.

9 Stimulation of commercial arbitration in order to eliminate the wastes of litigation.

10 Reduction of the waste arising from industrial strife between employers and employees.

What the country as a whole has accomplished during the past five years in increased national efficiency in these directions is beyond any possibility of measurement. Nor does the Department of Commerce lay claim to credit for the great progress that has been made, save as we may have helped to organize a definite public movement. That movement is the result of a realization by every group—business men, industrial leaders, engineers, and workers—of the fundamental importance of this business of waste elimination. In support of this movement we have had the benefit of notable advances in science, many inventions, much increased economic understanding, and prohibition.

Thanks to elimination of waste and these other contributing factors, we can as a nation show one of the most astonishing transformations in economic history, the epitome of which lies in the following table from the Department of Labor:

MOVEMENT OF WAGES AND PRICES, 1920–1926
[1913 = 100]

Year	Union wage rates	Prices[1]	Year	Union wage rates	Prices[1]
1920	199	226	1924	228	150
1921	205	147	1925	238	159
1922	193	149	August, 1926	238	150
1923	211	154			

[1] Average wholesale prices of all commodities.

These figures demonstrate one positive thing—the parallel increase of wages with decreasing prices.

ELIMINATION OF WASTE IN RAILWAY TRANSPORTATION

Probably the most outstanding single industrial accomplishment since the war has been the reorganization of our American railways. The railways, during the past five years, have built up adequate service and greatly reduced transportation costs.

No better indication of these accomplishments can be given than is shown in the following table, which shows increasing efficiency in every direction—equipment, management, and personnel

Fiscal years	Number of cars loaded	Tons, average train load	Car-miles per car-day	Average number of employees	Revenue freight ton-miles handled per employee	Revenue per ton-mile, cents
1921	42,332,670	687	24.4	1,869,501	214,667	1.179
1922	40,657,504	656	22.9	1,643,000	213,960	1.239
1923	47,192,796	704	25.7	1,770,000	243,523	1.126
1924	48,991,763	706	27.3	1,850,000	236,074	1.121
1925	49,677,771	731	27.3	1,765,169	247,788	1.108
1926	51,916,798	752	29.5	1,782,733	264,152	1.092

The result of this great reorganization upon the whole economic fabric of the country has been far-reaching. Rapid despatch has greatly reduced the inventories of the country, has contributed to stabilization of production and employment, and has increased the efficiency of all production and distribution.

Many unsolved problems in transportation confront us. Much thought must be given the coördination of our railway and water facilities. The economic relation between motor-truck and less-than-carload railroad distribution is important.

ELIMINATION OF WASTE THROUGH ENLARGED ELECTRIFICATION

In earlier publications of the Department, great emphasis was laid upon the possibilities of the elimination of waste which lay in the transformation of the power industry through the discoveries in the science of long-distance transmission and their application by large central generation plants feeding large systems and their interconnection with each other. Such savings lay in the greater economy production by saving fuel and labor by the larger central plants; the reduction of the amount of reserve equipment required; a better average load factor, and thus less equipment, through pooling of the daily and seasonal fluctuations, together with wider diversification in use; more security against interruption; better utilization of water power by applying it to base loads while making steam carry the peaks; utilization of secondary power from the seasonal flow of streams to the partial relief of steam; savings in industry by replacement of factory steam plants, the increased day load being supplied by the same generation equipment as night load for cities; the larger application of power in replacement of factory labor; and likewise the economies in the household and farm application of power.

All of these anticipated values have been realized in an extraordinary degree through the initiative and genius displayed in the electrical industry. The electrical generating capacity in the country has increased from 14,280,000 to 23,840,000 kw. in five years, an increase of 67 per cent. Although 66 per cent of our energy output is from fuel, the development of water power has been most active. Of the total of 8,300,000 water hp. now developed and connected into the systems, 2,500,000 hp. or some 43 per cent has been set to work in the last five years. The enormous savings that have been made in fuel consumption are indicated by the fact that while the electrical output of fuel-burning central stations increased 67 per cent

in five years, the fuel used increased less than 15 per cent. The average consumption of coal or its equivalent by such central electrical generation plants decreased from 3 pounds per kilowatt-hour in 1920 to 2.1 lb. during 1925, a saving at the average rate of 11,500,000 tons per annum; new water power effected a further annual saving equivalent to 3,100,000 tons.

There has been a large increase in the application of electrical power in manufacturing, and while there has been an increase during this period of between five and six million horsepower used in factory production, there has been no increase in boilers and engines installed within these plants, the increase having been made almost entirely by electrical motors operated through purchased power. There has also been a transformation from direct-connected steam equipment within factories to factory electrical generation for distribution throughout the plants until at the present moment apparently 70 per cent of factory power is delivered to the machines electrically.

The application of electrical power to home use has received enormous expansion. The number of homes served has increased in six years from 5,700,000 to over 15,000,000. The number of farms served is expanding rapidly, and in some states, such as California, farm electrification far exceeds that in any other locality in the world. Owing to the economies brought about through central generation and interconnection and through the advances in electrical science the average price of power throughout the country is now somewhat less than before the war, it being one of the few commodities to be delivered on less than a prewar basis.

This transformation, it may be said at once, has increased the productivity of our workmen beyond those of any other country; it contributes to our maintenance of high real wages and to the reduction of human sweat; it relieves the home makers of many irksome tasks and adds immeasurably to home comforts.

There is still further promise of great progress in the reduction of fuel consumption in the extension of electrification, particularly in the further replacement of factory steam plants, in the electrification of our large railway terminals, and the expansion of household use of power.

VIGOROUS UTILIZATION OF OUR WATER RESOURCES

Water is today our greatest undeveloped resource. Our streams and rivers offer us a possible total of 55,000,000 hp., and of this less than 11,000,000 has been developed. Of our 25,000 miles of possible inland waterways probably less than 7000 are really modernized, and the utility of much of these 7000 miles is minimized by their isolation into segments of what should be connected transportation systems. We still have 50,000,000 acres of possible reclaimable and irrigable lands which, while not now needed for agricultural production, will some day be absolutely necessary to supply growing population.

In its visualization of a policy of water development, the Department has indicated seven great projects of major importance: (1) Mississippi system; (2) Columbia River system; (3) Colorado River; (4) Great Lakes system; (5) the Great Valley of California; (6) intracoastal waterways; (7) other important developments, including the Rio Grande and Hudson River.

INCREASED BUSINESS STABILITY

As a contribution to greater stability, the Department has steadily enlarged its service of business statistics during the past five years. To this has been added a large increase in the statistical services of trade associations and our various economic and educational institutions. We are rapidly approaching the time when a business man will be able to determine the exact position of his industry in relation to production, stocks, orders, sales, conditions of sources of supplies, the consuming market, credit, business activity, and broad economic currents—both at home and abroad—which may influence the conduct of his particular occupation. The individual judgment has thus been greatly strengthened. Statistics are like weather reports in their relation to business conditions: they can be made to convey warnings of every incipient movement toward overproduction or inflation so that individual action becomes a great neutralizing force.

STANDARDIZATION AND SIMPLIFICATION

One of the major attacks upon industrial and commercial waste lies in standardization and simplification. By standardization we secure a positive approach through the establishment of definite notation in dimensions, quality, and performance of materials and machines which must be accompanied by the development of tests to be applied in the determination of the fulfilment of these standards. By simplification we secure a negative approach through elimination of the least necessary varieties, dimensions, or grades of materials and products. The usefulness of standardization and simplification is not limited in the application to materials and machines but is applicable to business practices such as specifications, and warehousing, financial, shipping, and other documents. And uniformity in such specifications reinforces the demand for standardized and simplified products.

Simplified-practice recommendations have been developed and accepted by manufacturers, distributers, and users for 45 commodities.

Simplified-practice recommendations for eleven items have been proposed and approved at general conferences of manufacturers, distributers, and users, and are now in process of acceptance by the various groups interested.

SCIENTIFIC RESEARCH

The progress of civilization depends in large degree upon "the increase and diffusion of knowledge among men." It is not simply the question of applying present-day science. We must add to knowledge through research in pure science. The improvement of some machine or process is of great value to the world, but the discovery of a law of nature, applicable in thousands of instances and forming a permanent and ever-available addition to knowledge, is a far greater advance.

COMMERCIAL ARBITRATION

The settlement of business disputes by arbitration instead of litigation has made important progress since 1921, progress being more particularly marked in the past fiscal year. The department has held that commercial-arbitration eliminates waste by removing ill-will, by saving costs of litigation, by preventing undue delays in business transactions, and by strengthening contractual relations.

NATIONAL COMMITTEES ON UTILIZATION OF WOOD AND METALS

Since 1921 a large number of coöperating committees have been set up in various industries and trades to work in conjunction with the Department of Commerce. In the past fiscal year there were 343 of these committees. To them and their predecessors is due in considerable measure the success of the Department's activities.

As a result of the experience gained by these committees the wood and the metal using industries proposed to the Secretary that there be set up special organizations to develop programs for the elimination of waste in their fields. The first of these, the National Committee on Wood Utilization, is composed of manufacturers, distributers, and consumers of lumber and wood products, and it works in close cooperation with official and private agencies. Its headquarters are in the Department of Commerce. It has for its object the utilization of wood in any form which, at present, is either wasted or not properly used.

The National Committee on Metals Utilization, organized in 1926, is composed of manufacturers, distributers, and consumers of metal and metal products. The committee is an impartial body made up of all branches of industry and trade interested in closer metal utilization, and better manufacturing, distributing, and metal-using practices. It is the purpose of the committee to carry the principles of simplified practice more deeply into the metals-using field. Unification of specifications and the discontinuance of certain undesirable trade practices are also included in the scope of the work.

FOREIGN TRADE

The large volume of forced exports of agricultural products during the war was bound to decline with the recuperation of European agriculture and the reëntry into world markets of producing centers isolated by the war. Consequently, if we were to maintain our purchasing power for import materials it was necessary that we increase our manufactured exports, the most competitive group. We could not rely on advantages in natural resources or on expansion of sales of non-competitive goods or on any fortuitous cause. Our factories pay the highest real wages in the world, yet we must needs export their products increasingly in the face of lower paid labor and depreciated currency abroad.

The success with which this export problem has been attacked by the American people and the American Government is witnessed by the fact that the value of our exports of finished and partly finished manufacturers in the fiscal year 1925–26 reached the huge sum of $2,572,000,000. This was an increase of 160 per cent over the prewar average and of 59 per cent over 1921–22. These classes constituted 47 per cent of our total exports from 1910 to 1914 and 60 per cent in 1925–26. Finished manufactures show even greater growth than partly manufactured goods.

AERONAUTICS

The air commerce act of 1926 (approved May 20) established a Federal policy with reference to commercial aeronautics and placed its administration under the Department of Commerce.

In general terms the act provides that the same essential services shall be given to navigation of the air which have been provided for over a hundred years in navigation of the water. The department is charged with the duty of registering eligible aircraft, certifying to their airworthiness, examining the operating personnel and air navigation facilities, also of establishing air traffic rules. It is authorized to lay out airways, provide for lighting, mapping, and emergency landing fields and in other directions furnishing assistance to aviators such as radio-direction fog-protection facilities, weather information, and other aids to navigation. The department is further charged with the general development and promotion of commercial aviation.

The purpose of the Government has been threefold—first, to secure better development of this new form of transportation for commercial purposes; second, to create private commercial services which can relieve the post office of its direct expenditure upon air mail; and third, by the creation of a large commercial air fleet with its accompanying personnel and its background of the manufacturing industry to give a fundamental military reserve to the country.

The work of the Department in development of the new aviation division has during the past fiscal year been of preparatory order.

LEGISLATIVE RECOMMENDATIONS

The law requires that the Secretary of Commerce shall include in his annual report "such recommendations as he shall deem necessary for the effective performance of the duties and purposes of the Department." Since March 4, 1921, the Department has made recommendations which have been accepted by Congress and legislation enacted directly or indirectly effected the results desired:

Revision of taxes upon Americans abroad engaged in commerce.
Establishment of commercial aeronautics in the department.
Regulation of Alaskan fisheries.
Construction of new departmental building.

Compensation for expert employees.
Improvement of the Lighthouse Service.

The following recommended legislation has now passed through one or both Houses:

Reorganization of the foreign commerce service of the Bureau of Foreign and Domestic Commerce.
Revision of radio regulation.

The following are recommendations for new legislation:

Revision of navigation laws.
Transfer of certain merchant-marine functions to the Department of Commerce and their consolidation under an assistant secretary for merchant marine.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The Hydraulic Laboratories of Europe

DIE WASSERBAULABORATORIEN EUROPAS (The Hydraulic Laboratories of Europe). With the collaboration of M. Carstanjen, H. Engels, W. Fellenius, Ph. Forchheimer, J. R. Freeman, M. Granz, H. Krey, W. Kruger, M. Möller, Th. Rehbock, Fr. Schaffernak, A. Schoklitsch, F. W. O. Schulze, A. Smreck, D. Thoma, V. E. Timonoff, and R. Winkel. Published by the Verein Deutscher Ingenieure under the direction of Dr. G. de Thierry and Dr. C. Matschoss. Berlin, 1926. 8 × 11 in., 431 pp., 512 illustrations.

THE appearance of this work in the original or German edition furnishes a most interesting and notable illustration of international coöperative engineering work. Mr. John R. Freeman, one of the foremost of American hydraulic engineers, traveling in Europe, became much impressed with the development of hydraulic laboratories in the countries visited, and especially in Germany, and with the high value and significance of the work which was being carried on in them. Himself a proponent of a national hydraulic laboratory for our own country, he was quick to appreciate the significance of these aids to hydraulic research and to realize the value to American hydraulic engineers, and to the world at large, of some first-hand account of these splendid foundations of experimental study in the broad domain of hydraulics.

Sharing these views with Dr. Conrad Matschoss, Secretary of the Verein Deutscher Ingenieure, he urged Dr. Matschoss to undertake the task of inducing the directors of these various laboratories to prepare each an account of his laboratory, its character and equipment, with some account of the more important problems which had been investigated therein.

Perhaps no more speaking characterization of the inception of this work can be found than these words translated from the introduction by Dr. Matschoss:

> Freeman, imbued with the most generous recognition of the scientific results which during his visit in 1924 he had noted in a number of European laboratories—he visited Berlin, Dresden, Brünn, Karlsruhe—desired most ardently to share with the great engineering world the advantages which he had thus enjoyed.

Dr. Matschoss willingly agreed to this undertaking, and in collaboration with Dr. G. de Thierry of Berlin the work was carried through with characteristic skill and thoroughness.

The contents comprise twenty chapters by eighteen different authors representing six different countries, as follows: Germany, Austria, Czechoslovakia, Sweden, Russia, and the United States, together with the free city of Danzig.

Sixteen of these chapters are descriptive of fourteen great European hydraulic laboratories, as follows: Braunschweig, Berlin, Charlottenburg, Darmstadt, Dresden, Karlsruhe, Munich, Wilhelmshaven, Danzig, Brünn, Graz, Vienna, Stockholm, and St. Petersburg. In addition, Mr. Freeman has contributed a chapter in which, among other valuable material, some account is given of the more important hydraulic laboratories in the United States. In the remaining three chapters Dr. H. Engels of Dresden writes on the historical development and on the value of model experimentation; Dr. R. Winkel of Berlin on the limits to which kinematic similitude may be employed in hydraulic-laboratory experimentation; and Dr. de Thierry, on a number of broad and important topics related to hydraulic laboratories and their use.

It is clear that no adequate idea of the contents of this composite work can be given in the space available for a brief review, but nevertheless some points here and there may be noted in order to give a better indication of the wealth of material to be found.

First referring to the chapter by Mr. Freeman, translated into German by Dr. de Thierry, there are given, by way of introduction, some general considerations on research in hydraulic laboratories, followed by a sketch of the development of the concept of the study of hydraulic problems by way of laboratory equipment, and with special mention of the study of the problems of river flow through model construction. Then follows a list of some 65 problems which might receive effective study through laboratory methods and facilities. The author points out that this list is the one which he had previously presented in a paper read before the American Society of Civil Engineers and that it is far from exhaustive—rather suggestive than otherwise—and that other engineers might readily extend the list in accordance with their own experience.

Then follows a brief historical sketch of the development of hydraulics as a factor in the advance of civilization with reference to the contributions of Vitruvius, Frontinus, Leonardo da Vinci, Galileo, and others.

The author gives next a summary account of the more important experimental researches carried on in the United States, with a brief description of the means available and utilized. These include the Francis experiments at Lowell; the Mills research on the measurement of stream flow; the research of the water department of Boston on the same subject; the Holyoke laboratory for turbine tests; the researches of Hamilton Smith, Jr., on flow in pipe lines and on the efficiency of impulse water wheels; the 115 studies of Herschel on pipe-line flow, venturi meters, and other important subjects; the researches of Gilbert on the movement of heavy material in water; the researches of the Miami River Conservancy Board; the researehes of the U. S. Interior Department (Reclamation Service) on various subjects connected with stream flow; together with a brief account of his own researches on a wide variety of hydraulic problems including the classic studies on fire-hose streams.

The second chapter, on the historical development and the significance of research through the use of models, is by Dr. Von Engels of Dresden. A brief historical sketch is first given, indicating the more important points in the development of the theory

of model experiments and their application in research, followed by a general discussion of the significance and use of such methods in the study of hydraulic problems, and including a number of illustrative examples.

This chapter is followed by a chapter on the limits of application of model research as based on geometric and kinematic similitude, written by Dr. Von Winkel of Berlin.

This chapter deals with the theory of model research as based on kinematic similitude and points out in various directions the limitations which must be recognized in the application of the method. In particular, the fact that the atmospheric pressure in both model and full-scale measurements is usually the same while elements of water pressure are in the ratio of the vertical dimensions, is pointed out as nullifying the strict pressure relation between model and full scale, and note is made of the extent to which this departure may be compensated for or disregarded.

Note is also made of the impossibility of completely fulfilling at the same time all requirements for kinematic similitude as regards friction and pressure factors, and the influence of this departure from complete similitude is discussed.

Reference is also made to the influence of the difference in scale between horizontal and vertical dimensions as between model and full scale, and to the impossibility of reproducing in the model, in proportional dimensions, turbulent movements of the full scale. The difficulty of dealing with material rolled or entrained along a stream bed (*geschiebe stoff*) is also pointed out at length, and caution is given as to the interpretation of model results when such is an important element.

There is given likewise some general discussion of the ratio between model and full scale for the various kinematic, force, flow, and energy relations which are commonly involved in hydraulic problems.

In all, this chapter is one of the most important in the book, pointing out as it does the caution which must be exercised and the limitations which must be recognized in the use of models for the study of hydraulic problems.

The remaining chapters, with the exception of the last, deal with descriptive matter. The last chapter, contributed by Dr. de Thierry, is entitled "Closing Word" and deals with a number of important topics.

It opens with a graceful tribute to Mr. Freeman and intimates that without the trust, confidence, and respect with which he is held throughout Europe, the preparation of the various memoirs descriptive of the installation and equipment of these various laboratories and of the important problems investigated in them would hardly have been a possible undertaking.

Dr. de Thierry then discusses the possibility of a closer cooperative relation between the various world hydraulic laboratories, the vast extent of the field, and the very considerable results which have been accomplished in the existing installations—far more than could be reported within the limitations of space imposed on the several contributions—and hence the need of some more carefully studied scheme for international coöperation.

He incidentally refers to a hydraulic laboratory considered as an aid in the economical construction of hydraulic works, as a necessity and not as a luxury, and points out economies in construction in Germany already far exceeding the costs of installation and operation.

He then discusses in general terms hydraulic problems and their treatment, especially when studied through the aid of reduced-scale models. The subject of hydraulic laboratories for instruction is then referred to and special emphasis is placed on the need of such laboratories as a part of the material for the training of hydraulic engineers, not only to familiarize them with the uses of such installations and the methods of making the various measurements involved in the study of hydraulic problems, but also as an incentive to and as a means for continued research on problems yet awaiting further study.

Suggestions are then given regarding future laboratories, especially as regards their size, capacity, length of canal, etc., in order that too serious limitations may not enter into the study of certain problems.

Dr. de Thierry then gives a rapid glance over the more important conclusions reached as a result of previous researches and points out directions in which these studies should be extended.

The remaining sixteen chapters are descriptive in character, dealing, as previously noted, with fourteen hydraulic laboratories, giving their equipment, copiously illustrated with plans, diagrams, and with notes of the more important lines of study and special problems which have been undertaken in them. No attempt can be made to give in any detail the contents of these chapters. They form a unique ensemble of information regarding hydraulic laboratories, their construction, equipment, administration, and operation, and problems which may be studied effectively on model scale—with numerous actual examples, the whole making a collection of information to be found nowhere else in the world and of incalculable value to engineers having to deal with problems of hydraulic design and construction.

It is understood that the chapters of this book are now being translated by a number of eminent American hydraulic engineers and that in the near future an edition in the English language may be looked for. This will place the book, and its vast store of information, at the immediate service of the English-speaking world and will thus enormously widen its field of usefulness. The entire engineering world and the English-speaking section in particular owe a deep debt of appreciation to Mr. Freeman, to the V.D.I., its secretary Dr. Matschoss, to Dr. de Thierry, and to the various other contributors for the interest and labor which have made possible the placing before the engineering fraternity of this unique and most valuable collection of information regarding the world's great hydraulic laboratories, their construction, equipment, and operation, and the problems which have been and may be advantageously studied on model scale in laboratory installations of the character described.

W. F. DURAND.[1]

Books Received in the Library

CAST IRON FOR DIESEL ENGINES. By A. Campion. E. & F. N. Spon, London, 1926. (Reprint of paper read before The North East Coast Institution of Engineers and Shipbuilders, January 22, 1926.) Paper, 6 × 10 in., 27 pp., illus., diagrams, 3s.6d.

The unusual conditions of temperature and stress to which oil engines are subjected have given rise to much trouble with cast-iron parts. The present pamphlet discusses the effect of these conditions upon the strength, growth, hardness, and structure, the metallurgical principles which must be applied in determining the type of iron to be used for the various parts of the engine, and the factors concerned in the production of metal which will retain its strength at the temperatures encountered, will not change in shape or size and will resist abrasion.

DER GENAUIGKEITSGRAD VON FLÜGELMESSUNGEN BEI WASSERKRAFTANLAGEN. By A. Staus. Julius Springer, Berlin, 1926. Paper, 6 × 9 in., 35 pp., illus., diagrams, tables.

The current meter is almost universally used for measuring water powers in continental Europe, while in this country and England other methods are generally preferred. This variance in custom has led Dr. Staus to investigate the accuracy of current meters to ascertain what justification there may be for our distrust of them.

His monograph first systematically discusses all the possible ways in which errors in measurement may arise, through the selection of the point of measurement, the plotting of the profile, the meter itself, the time measurements, the method of measuring the velocity, and the calculation of results. Various improvements are suggested. At the close the degree of accuracy obtainable with current meters is reviewed. A very thorough bibliography is included.

JAHRBUCH DER BRENNKRAFTTECHNISCHEN GESELLSCHAFT, 1925. Wilhelm Knapp. Halle, Saale, 1926. Paper, 8 × 11 in., 73 pp., illus., 4 r.m.

In addition to an account of the proceedings at the annual meeting held in 1926 at Charlottenburg, the Year Book contains a paper on the technical development, possibilities and economic importance of pulverized fuel, by Dr. Helbig, and one on mechanical firing for boilers, by E. Baurichter.

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THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

Mechanical Engineering Section

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AERONAUTICS

German Developments. Report of the Meeting of the German Scientific Society for Aeronautics in Düsseldorf (Bericht über den Verlauf der XV. Ordentlichen Mitgliederversammlung der Wissenschaftlichen für Luftfahrt (WGL) vom 16–20. Juni 1926 in Düsseldorf), G. v. Scheve. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 13, July 14, 1926, pp. 275–286. Review of papers and formal addresses presented before W. G. L.; Perlewitz spoke on meteorological conditions above Atlantic Ocean; Rohrbach emphasized his preference for all-metal airplanes, especially duralumin; H. Hermann discusses bodies and floats of flying boats; he considers hydroplanes with two floats better than flying boats for total weights of 2 or 3 tons; for larger craft flying boat is superior; B. Spieweck spoke on photographic studies of starts and landings; Seewald, on deformations of propellers; v. Karran, on problems of modern airplane statics; etc. See brief translated account in Automotive Abstracts, vol. 4, no. 9, Sept. 20, 1925, p. 268.

Digest of Some of the Speeches Made at the Fifteenth Regular Meeting of the "Wissenschaftliche Gesellschaft für Luftfahrt" June 17, 1926, in Dusseldorf, Germany. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 379, Sept. 1926, 15 pp. Lecture by Rohrbach dealt mainly with questions of material and manufacturing; H. Herrmann discussed seaplane hulls and floats; B. Spieweck spoke on photogrammetric starting and landing measurements; F. Seewald on theoretical and experimental determination of propeller deformations; von Karman, on experimental problems of modern aircraft stations; Scheubel, on tail flutter and how to avoid it; Weidinger and Schrenk, on determination of wing-section drag of airplane in flight; Rumpler, on problem of trans-ocean airplane. Translated from Zeit. für Flugtechnik u. Motorluftschiffahrt, July 14, 1926.

AIR COMPRESSORS

Piston. Varying Efficiency of Piston Compressors (En kolvkompressors olika verkningsgrader), B. G. Markman. Jernkontorets Annaler, no. 1–6, 1926, pp. 242–265, 15 figs. Discusses efficiency and mechanical work; determination of efficiency, indicator diagrams, etc.; rules for testing compressors.

Oil-Engined. Oil Engine-Driven Air Compressor. Engineer, vol. 142, no. 3689, Sept. 24, 1926, pp. 333–334, 4 figs. 50-hp. direct-connected cold-starting oil engine and air compressor introduced by Ingersoll-Rand Co.; installation has been in continuous operation for some time in Derbyshire mine, where it is supplying air at pressure of 100 lb. per sq. in. for power purposes.

AIR CONDITIONING

Department Stores. Air Conditioning and Cooling in Hudson Stores, D. C. Lindsay. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1120–1122, 4 figs. Experience has taught operators of department stores that temperature and humidity of atmosphere within store reacts directly upon volume of business; system installed in Detroit department store; new refrigerant, known as dichlorethylene, was used.

Refrigeration Applied to. Refrigeration as Applied to Air Conditioning, A. Lewis. Domestic Eng. (Lond.), vol. 46, no. 9, Sept. 1926, pp. 179–182, 4 figs. Air conditioning of automatic telephone exchanges where it is stipulated that humidity should not exceed 70 per cent and that air should be clean.

AIRPLANE ENGINES

National Air Races. Power Plant Aspects of the National Air Races, E. E. Wilson. Aviation, vol. 21, no. 13, Sept. 27, 1926, pp. 543–544, 3 figs. Points out that advent of air-cooled pursuit planes is outstanding development of past year.

Two-Stroke. Power Output and Air Requirements of a Two-Stroke Cycle Engine for Aeronautical Use, C. R. Paton and C. Kemper. Nat. Advisory Committee for Aeronautics—Report, no. 239, 1926, 11 pp., 12 figs. Investigation at Langley Field, Va., to determine pressure and amount of air necessary for satisfactory high-speed, two-stroke-cycle operation, thus permitting power requirements of air pump or blower to be determined.

AIRPLANE PROPELLERS

Model Tests. Report on Tests of Metal Model Propellers in Combination with a Model VE-7 Airplane, E. P. Lesley. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 245, Aug. 1926, 15 pp., 18 figs. Tests of three model propellers, in free air stream and in front of model of VE-7 airplane; effect of introducing model airplane is shown to be increase in thrust and power coefficients and efficiency at small slip, and decrease in same at large slip.

Vortex Ring States. The Analysis of Experimental Results in the Windmill Brake and Vortex Ring States of an Airscrew, H. Glauert. Aeronautical Research Committee—Reports and Memoranda, no. 1026, Feb. 1926, 8 pp., 2 figs. Experimental data have been analyzed to determine form of characteristic curve in regions where vortex is inapplicable or inaccurate.

AIRPLANES

Albatros. New Two-Engine Albatros Passenger Biplane L73 (Der neue zweimotorige Albatros-Verkehrsdoppeldecker L 73). Luftfahrt, vol. 30, no. 14, July 20, 1926, pp. 212–213, 3 figs. New metal design for carrying 8 passengers, equipped with two engines of 240 hp. of B.M.W. type, 560 km. radius of action, velocity, 140 km. per. hr.; total load 4610 kg., empty 2914 kg.

The Albatros L. 73. Flight, vol. 18, no. 36, Sept. 9, 1926, pp. 562–564, 4 figs. German biplane with two 240-hp. B.M.W. type-IV engines.

All-Metal. Recent Development in the Construction and Operation of All-Metal Airplanes, C. Dornier. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 378, Sept. 1926, 23 pp., 24 figs. Tendency to use steel wherever possible is more pronounced today than ever before; new possibilities have been opened up by rustproof steels recently put on market; results of systematic experiments with all new steels and light alloys; brief review of development of landing gears and airplanes produced by author's company during last few years. Translated from Berichte und Abhandlungen der Wissenschaftlichen Gesellschaft für Luftfahrt, May 1926.

Autorotation. Experiments on Autorotation (Untersuchungen über Autorotation), E. Anderlik. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 16, Aug. 28, 1926, pp. 338–342, 15 figs.; also translation in Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 380, Sept. 1926, 18 pp., 15 figs. Experiments include (1) systematic comparsion of various wings in autorotation, in connection with which effect of index value was also studied; (2) investigation of effect of side wind on autorotation; (3) investigation of resistance or drag of rotating wing; discusses also measurement of pressure distribution on rotating wing.

Cole. The Cole Sport Commercial Airplane. Aviation, vol. 21, no. 15, Oct. 11, 1926, p. 642, 1 fig. New two-seater with OX-5 engine; which is tandem single-bay biplane.

Dynamics. Buoyancy of Airplanes and Altitude Attainable (Il sostentamento degli aerei e la quota raggiungibile), A Crocco. Rivista Aeronautica, vol. 2, no. 7, July 1926, pp. 18–40, 1 fig. Mathematical treatment of statics and dynamics of airplanes and airships; laws of sustaining power in air, comparative efficiency curves, etc.

Engineering Aspects. The Engineering of the Modern Airplane, E. P. Warner. Boston Soc. of Civ. Engrs.—Jl., vol. 13, no. 7, Sept. 1926, pp. 312–321 and (discussion) 321–323, 1 fig. Points out that airplane by very conditions under which it operates, includes hazards and special difficulties which can only be overcome in advance, or eliminated in course of work by application of engineering methods and scientific analysis; present-day airplane in respect to its form and size and its performance; problem of structural arrangements.

Flying Boats. See FLYING BOATS.

Light. British Light Plane Development and Lympne Meeting. Flight, vol. 18, no. 36, Sept. 9, 1926, pp. 565–584, 36 figs. History of light-airplane movement in Great Britain; first and second Lympne meeting; account of this year's meeting; 1926 machines; engines. See also account of performance in no. 37, Sept. 16, 1926, pp. 592–603, 26 figs.

Meyers Midget. The Meyers Midget. Aviation, vol. 21, no. 14, Oct. 4, 1926, pp. 592–594, 2 figs. New 30-hp. light plane is very small single-seater biplane with Bristol Cherub III engine.

Rotor System. Experiments with Rotating Cylinders in Combination with Airfoils (Versuche mit rotierenden Zylindern in Verbindung mit Tragflächen), K. Frey. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 16, Aug. 28, 1926, pp. 342–345, 7 figs.; also translation in Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 382, Oct. 1926, 11 figs., 7 figs., part on supp. plate. Results of tests in wind tunnel of Hannover Technical High School, in endeavor to find utilizable polar for landing and for horizontal flight; it was found that solution of problem involves very great though not necessarily insurmountable difficulties.

Seaplanes. See SEAPLANES.

Tailless. The Tailless Aeroplane, G. T. R. Hill. Roy. Aeronautical Soc.—Jl., vol. 30, no. 189, Sept. 1926, pp. 519–538 and (discussion) 538–544, 15 figs. Basic principles involved; functions of airplane controls; power of normal controls; evolution of tailless design; details of experimental work; results of flight tests.

Take-Off. Method for Graphic Investigation of Take-Off Conditions of an Airplane (Verfahren zur graphischen Untersuchung der Startverhältnisse eines Flugzeugs), F. Z. Diemer. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 15, Aug. 14, 1926, pp. 325–326, 2 figs. Gives symbols for list of terms employed; how take-off is calculated; determination of curves for air resistance, ground friction, propeller thrust, etc.

Take-Off Distance for Airplanes (Die Startstrecke bei Flugzeugen), A. Pröll. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 15, Aug. 14, 1926, pp. 316–322, 6 figs.; also translation in Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 381, Sept. 1926, 25 pp., 6 figs. Conditions for taking off differ greatly from those for landing; possi-

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

bility of shortening take-off run; discusses two principal ways in which total take-off distance can be reduced to minimum: (1) taxying and hovering until maximum speed has been attained close to ground and then changing to steep rapid climb; (2) lifting airplane from ground as soon as possible and then climbing at relatively large angle of attack.

Wings. Formulas for Comparison of Polar Loci (Formules de comparaison des polaires Influence de l'allongement des cellules), M. Roy. Aérophile, vol. 34, nos. 15–16, Aug. 1–15, 1926, pp. 241–246, 7 figs. Develops formulas for comparing wings of same type and different extension; tests of wings of different types to determine value of relative depth.

Method of Calculating Lifting Force of Given Profiles of Supporting Surfaces (Verfahren zur Berechnung des Auftriebes gegebener Tragflächen-Profile), F. Höhndorf. Zeit. für angewandte Mathematik u. Mechanik, vol. 6, no. 4, Aug. 1926, pp. 265–283, 11 figs. Mathematical determination of coefficients of function of transformation for given profile, i.e., reduction of profile to circle.

Wind Channel Tests of Slot and Aileron Control on a Wing of R. A. F. 15 Section, F. B. Bradfield, A. S. Hartshorn and L. Caygill. Aeronautical Research Committee—Reports and Memoranda, no. 1008, Nov. 1925, 29 pp., 11 figs. Part I: When central portion of wing is R. A. F. 15. Part II: When central portion of wing is slotted and fitted with flap.

AIRSHIPS

Semi-Rigid. A New Airship (Ein neues Luftschiff), L. Kort. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 16, Aug. 28, 1926, pp. 336–338, 3 figs. Shows that principle of semi-rigid airship can be successfully applied to very large airships, and that it even possesses certain advantages over rigid type, with regard to effective load, impact resistance, and construction costs; describes new design, which is fish-shaped; length is less, diameter is greater than ZR-3 (Los Angeles); volume is the same (70,000 cu.m.); weight comparison with Los Angeles.

ALCOHOL

Automotive Fuel. Alcohol as Automotive Fuel (Alkohol als Motoren-Brennstoff), E. Fischer. Motorwagen, vol. 29, no. 21, July 31, 1926, pp. 487–493, 15 figs. Investigation of use of alcohol as automotive fuel and advantages of its use, in comparison with disadvantages.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Brass. See BRASS.

Bronzes. See BRONZES.

ALUMINUM

Castings. Aluminum Casting Output, Its Difficulties, R. Micks. Can. Foundryman, vol. 17, no. 9, Sept. 1926, pp. 32 and 37–39, 6 figs. Difficulties involved in production of aluminum castings, and improvement in practice; use of chloride of zinc; describes two types of machines.

Corrosion Resistance. Effect of Thermal and Mechanical Treatment of Aluminum on its Resistance to Corrosion (Ueber den Einfluss der thermischen und mechanischen Behandlung von Aluminium auf seine Korrosionsbeständigkeit), W. Wiederholt. Korrosion und Metallschutz, vol. 2, no. 5, May 1926, pp. 126–133, 11 figs. Discusses tests carried out at Reichsanstalt with commercial aluminum; effect of annealing on velocity of dissolution of aluminum in hydrochlorine and in soda lye; recrystallization, conductivity, resistance, etc.

ALUMINUM ALLOYS

Alpax. Some Mechanical Tests of Cast Bars of Alpax, H. J. Tapsell. Aeronautical Research Committee—Reports and Memoranda, no. 1011, Dec. 1925, 9 pp., 2 figs. Results obtained from tests to determine mechanical properties at air temperature and at elevated temperatures of cast silicon-aluminum bars; it is shown that this material is valuable casting alloy; ultimate tensile strength compares favorably with that of chill-cast Y alloy.

Special Alpax Metals (Les Alpax spéciaux), M. Petit. Revue de Métallurgie, vol. 23, nos. 7 and 8, July and Aug. 1926, pp. 418–431 and 465–484, 53 figs. Discusses research work to obtain an Alpax metal of 13 per cent Si content, of better mechanical and physical properties, by addition of one or several other metals; heat treatment of special Alpax metals; velocity of cooling, etc.; micrographic examination; inconclusive results.

Castings. Aluminum-Alloy Permanent-Mold Castings, H. J. Anderson. Am. Foundrymen's Assn.—Preprint no. 5, for mtg. Sept. 27–Oct. 1, 1926, 29 pp., 10 figs. Indicates directions which have been taken by more recent developments in aluminum-alloy permanent-mold casting; discusses properties, mode of manufacture and fields of application, and gives comparison with sand and die castings; it is shown that aluminum-alloy permanent-mold castings have greater soundness, finer grain size, greater strength and hardness, greater resistance to impact and alternating-fatigue stresses, and greater resistance to corrosion than sand castings.

Recent Developments in the Production of Aluminum-Alloy Castings, R. J. Anderson. Am. Metal Market, vol. 33, no. 180, Sept. 18, 1926, pp. 9–10, and 13–14, 9 figs. Applications of aluminum-alloy castings; alloys for casting production; melting in foundry practice; heat treatment of castings; sand-casting and die-casting practice; permanent-mold casting.

Constitution. Constitution of Alloys of Aluminum, Zinc and Tin and Aluminum, Zinc and Cadmium, V. Jares. Am. Inst. Min. & Met. Engrs.—Trans., no. 1588-E, for mtg. Sept. 1926, 15 pp., 17 figs. Results of experiments on binary and ternary alloys.

AMMONIA COMPRESSORS

Refrigerating Capacity. Refrigerating Capacity of Ammonia Compressors, W. H. Motz. Refrigeration, vol. 40, no. 3, Sept. 1926, pp. 44–46, 1 fig. Refrigerating and ice-making capacities of ammonia compressors; effect of evaporator and condenser pressures; practical problems on capacities.

Vertical Double-Acting. Ammonia Compressor Design, E. Markham. Cold Storage, vol. 29, no. 342, Sept. 16, 1926, pp. 389–390. Advantages possessed by vertical double-acting machine over other types.

Vertical-Shell and Tube-Type. Test of Vertical Shell and Tube Type Ammonia Condenser, F. R. Zumbro. Refrig. Eng., vol. 13, no. 2, Aug. 1926, pp. 49–57 and (discussion) 57–63 and 67, 13 figs. Results of tests made for purpose of obtaining such data as would enable one to prophesy, with reasonable accuracy, performance under various conditions; numerous advantages of this type of condenser.

ASH HANDLING

Hydraulic. Hydraulic Ash Disposal Proves Economical, L. C. Shelain. Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, pp. 1046–1048, 2 figs. System developed by Rockford Elec. Co., during war-time emergency, is simple and economical.

Hydraulic Removal of Ashes at the Paris Electricity Co.'s Northern Works (L'enlèvement hydraulique des machefers à l'Usine Nord de la Compagnie Parisienne de Distribution d'Electricité), C. Postweiler. Génie Civil, vol. 89, no. 9, Aug. 28, 1926, pp. 179–181, 3 figs. Describes system which has advantage that no piece subject to wear comes in contact with ashes, thus practically eliminating attendance and lubrication.

AUTOMOBILE ENGINES

Atomizers. The Hobson Atomiser. Automobile Engr., vol. 16, no. 219, Sept. 1926, pp. 334–335, 3 figs. New device to provide distribution and facilitate induction-pipe design.

Casting-Inspection Fixtures. Two Engine-Casting Inspection Fixtures, A. R. Fors. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 370–372, 8 figs. Describes fixture for checking unit cylinder-and-crankcase blocks to assure that castings will be machined correctly; other device is gage for checking depth of combustion chambers in cylinder-head castings to assure that they will have equal volumetric capacity and to eliminate expensive operation of machining them.

Sleeves. Inspection of Knight Engine-Sleeves, J. B. Scott. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 351–355, 12 figs. After illustrating rough and finished sleeve, author exhibits microstructure of metal used and states physical properties desired; normalizing process for removal of casting strains and method used for determining hardness of sleeves; tolerances that are allowed; finish-boring operation; details of inspection.

AUTOMOBILES

Hanomag. The Hanomag Light Car. Automobile Engr., vol. 16, no. 219, Sept. 1926, pp. 318–322, 14 figs. Automobile constructed by Hannoversche Maschinenbau, A. G., Hannover, Germany; single-cylinder water-cooled engine is mounted vertically at rear end of chassis, crankshaft being arranged parallel to axles; radiator is situated at rear of engine; general outline of cars is one which sufficiently approximates to streamline form devoid of externals to considerably reduce wing resistance.

Headlights. Compromises in Headlighting. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 341–342. Suggestions based on preliminary observation with four-lamp test equipment; types of headlight compromise compared; self-protective feature of adjustable beam; device suggested to secure beam adjustment.

Pneumatic Suspension. Pneumatic Suspension, E. B. Killen. Motor Transport, vol. 43, no. 1123, Sept. 20, 1926, pp. 361–362, 4 figs. Complete pneumatic suspension to eliminate all unsprung parts of any chassis under all running conditions has recently been made possible by introduction of variable-to-load tire which increases in effective strength with increase of load and can safely carry overload.

Steering Gears. Press Operations on Marmon Steering Gear Parts, F. W. Curtis. Am. Mach., vol. 65, no. 15, Oct. 7, 1926, p. 601, 1 fig. Layout of operations required to form cup; details of dies used for drawing body; trimming outside flange; die for notching eight slots in small end.

Automobile Steering Mechanism Design, R. L. Rolf. Forging—Stamping—Heat Treating, vol. 12, nos. 8 and 9, Aug. and Sept. 1926, pp. 266–270 and 343–347, 23 figs. Design and fabrication.

Steyr. A New Small "Six." Autocar, vol. 57, no. 1609, Sept. 3, 1926, pp. 375–376, 3 figs. Independently sprung rear wheels, liveliness and flexibility are features of 14–35-hp. Steyr.

Sunbeam. The New 25 H.P. Six-Cylinder Sunbeam. Auto-Motor Jl., vol. 31, no. 34, Sept. 9, 1926, pp. 705–708, 12 figs. Engine is monobloc construction and in unit with clutch case and gear box, whole being supported in deep-pressed steel chassis frame; cooling is effected by very capacious centrifugal pump, driven by silent-chain distribution gear and in tandem with dynamo and magneto on near side of engine; carburetor is vertical Claudel-Hobson.

Wolseley. The 16–45 H.P. Wolseley Light Six. Auto-Motor Jl., vol. 31, no. 35, Sept. 16, 1926, pp. 729–732, 10 figs. New two-liter model with overhead valves; 4-wheel brakes.

AUTOMOTIVE FUELS

Alcohol. See ALCOHOL.

Anti-Knock. Effects of Anti-Knock Materials on Spontaneous Ignition Temperatures of Some Inflammable Liquids, Y. Tanaka and Y. Nagai. Imperia Academy (Japan)—Proc., vol. 2, no. 5, May 1926, pp. 221–223. Investigation of effects of diethyl selenide, tetraethyl lead, aromatic amines, and pyridine on spontaneous-ignition temperatures of some inflammable liquids; it was found that effects of these compounds were parallel to those of water described in previous report. (In English.)

B

BEARINGS

Journal. Reclaiming Journal Bearings at the Great Northern Shops, F. W. Curtis. Am. Mach., vol. 65, no. 13, Sept. 23, 1926, pp. 519–520, 4 figs. Furnace for melting worn linings and reclaiming old bearing metal; boring, facing, and relining brasses; relined brasses are finished by milling.

BEARINGS, ROLLER

Barrel-Shape Rollers. A New Roller Bearing (Ein Neues Walzlager), M. Gohlke. Maschinenbau, vol. 5, no. 17, Sept. 2, 1926, pp. 794–798, 11 figs. Details of Fischer barrel bearing and tests carried out with it at Dahlem State Testing Station, showing that corresponding breaking loads of cylindrical and of barrel bearings are 190 to 250 tons.

Mounting Methods. Roller Bearing Mounting Methods. Am. Mach., vol. 65, no. 14, Sept. 30, 1926, p. 563, 6 figs. Reference-book sheet.

BELT DRIVE

Efficiency. Efficiency in Belt Drives. Automobile Engr., vol. 16, no. 219, Sept. 1926, pp. 337–338. Points out necessity for cleanliness; belt dressings and capacities; jointing belts.

Small. Small Belt Drives. Machy. (Lond.), vol. 28, no. 723, Aug. 19, 1926, pp. 581–583, 8 figs. Their general application, types of belts used, and design of efficient pulleys.

BOILER FEEDWATER

Impurities. Water and Its Impurities, J. C. Moore. Power House, vol. 20, no. 17, Sept. 5, 1926, pp. 17–19. Effect of impurities in feedwater of boilers is to cause deposition of scale on interior of water-heating surfaces, in addition to deposition of mud or sediment, thus facilitating corrosion and foaming; corrosion results mainly from use of hard water; causes of hard water; how deposit becomes hard; carbonates of magnesia; alkalinity of water; test for calcium salts; treatment to prevent scale; water filtration.

Preheating Pump. Preheating Pump, E. Josse. Eng. Progress, vol. 7, no. 8, Aug. 1926, pp. 208–209, 3 figs. Details of pump manufactured by firm of F. Seiffert & Co., Berlin, novel feature of which is that boiler feedwater is heated inside pump in direct contact with bleeder steam, pump raising pressure of condensate of prime movers fed back to boilers, from condenser pressure to boiler pressure.

Regulators. Campbell Boiler Feed Regulator. Paper Trade Jl., vol. 83, no. 13, Sept. 23, 1926, pp. 48–49, 1 fig. New regulator has no moving parts and is simple hollow casting with inlet, outlet and pressure port; describes how it works and its numerous advantages.

Treatment. Treatment of Feed Water. Nat. Elec. Light Assn.—Report, no. 256–71, July 1926, 30 pp., 21 figs. Results in several plants with use of sodium aluminate as accelerator in outside treating systems, and experience with acid treating apparatus used in connection with zeolite system; scale troubles in interdeck and radiant-heat-type superheaters; boiler-scale troubles in high-pressure plant, which has been endeavoring to maintain suggested sulphate-carbonate ratio; caustic-embrittlement troubles with boilers at Long Beach steam plant of Southern California Edison Co.; acid treatment of boiler water as developed by Dallas Power & Light Co.

BOILER FURNACES

Air Preheaters. Operation of the Ljungstrom Air Preheaters, B. G. Brolinson. Iron & Steel of Canada, vol. 9, no. 9, Sept. 1926, pp. 227–235 and (discussion) 235–236, 21 figs. Differs materially from all other air preheaters because regenerating principle is employed, that is, heat is carried from escaping flue gases to incoming air continually in mechanical way, but by means of slowly rotating regenerator containing very large heating surface within narrow limits; at same time counterflow principle is applied. Paper read before Can. Pulp and Paper Assn.

Clinker Disposal. Methods of Clinker Disposal on Furnace Side Walls Using Chain Grate Stokers, F. Dawson. Eng. & Boiler House Rev., vol. 40, no. 3, Sept. 1926, pp. 124–128, 3 figs. American methods and devices.

Destructor. The Industrial Steam Raising Destructor, D. Wilson. Power Engr., vol. 21, no. 247, Oct. 1926, pp. 377–378, 1 fig. Combined destructor furnace and water-tube boiler for dealing with refuse daily available from case and box-making factory; boiler portion of plant is of Vickers patent portable type.

Stoker-Fired. Stokers and Furnaces. Nat. Elec. Light Assn.—Report, no. 256–257, June 1926, 80 pp., 94 figs. Few of new furnace installations, or those contemplated, are without water screening in some form or other; experimenting along lines of mixing and elimination of stratification in furnace gases; design of stoking equipment to meet demands for higher capacities; application of air-cooled walls to pulverized-fuel furnaces; air-heater performance, indicating increasing popularity of this apparatus; refractories.

BOILER PLANTS

Coal Mines. New Boiler Plant of the Consolidation Mine (Die neue Kesselanlage der Schachtanlage 3-4-9 der Zeche Consolidation), V. Hundertmark and H. Reiser. Glückauf, vol. 62, no. 30, July 24, 1926, pp. 961-966, 8 figs. Plant designed for firing low-grade fuels, sludge, middlings, coke, ash, etc.; Piedboeuf two-header water tube; boilers of 300 sq. m. heating surface and 90 sq. m. superheat; tests give excellent results.

Instruments. Boiler and Turbine Room Instruments. Nat. Elec. Light Assn.—Report, no. 25-107, Jan. 1926, 23 pp., 28 figs. Gives operating experiences of companies with instruments of many kinds, and description of numerous applications of instruments to solution of power-plant problems.

Pulverized-Coal. Pulverized Fuel Plant and Boilers for Messrs. Synthetic Ammonia and Nitrates, Limited. Engineering, vol. 122, no. 3167, Sept. 24, 1926, pp. 381-383, 14 figs. partly on p. 388 and supp. plate. Installation comprises two Thompson 4-drum water-tube boilers fitted with Thompson superheaters, Foster economizers and Usco air heaters; Lopulco system of firing pulverized coal has been adopted, mills being of Raymond roller type and burners and furnaces with their water-cooled elements follow standard Lopulco practice.

Safety of Operation. Safety of Operation in the Steam Plant. Nat. Elec. Light Assn.—Report, no. 256-268, July 1925, 6 pp., 6 figs. Deals with general hazards of boiler room and special hazards incident to pulverized coal.

BOILER PLATE

Caustic Embrittlement. Concentrations of Caustic Soda in Connection with Boiler Plate (Laugenkonzentrationen in Verbindungen von Kesselblechen), R. Baumann. Archiv fur Warmewirtschaft, vol. 7, no. 9, Sept. 1926, pp. 255-260, 16 figs. Results of investigation carried out for German Union of Boiler users, showing that supposed concentration of salts, especially of caustic soda, in rivet seams is only possible if seams are leaky and feedwater is very salty.

Tightening Machine. A Pneumatic Boiler Plate Tightening Machine. Eng. & Boiler House Rev., vol. 40, no. 3, Sept. 1926, pp. 132-135, 3 figs. Machine known as Hallett Patent Pneumatic Plate Tightening Machine, consisting essentially of two sets of double toggles operated by opposed pistons traveling in pressed-steel cylinders.

BOILERMAKING

Riveted and Welded Joints. Riveted and Welded Joints in Boiler Construction. Engineering, vol. 122, no. 3170, Oct. 15, 1926, pp. 489-490. Report of work done by M. Hoehn, chief engineer of Swiss Association of Steam Boiler Owners, making comparisons of characteristics of boiler drums forged in single piece with those having riveted and welded joints of various types, either separately or in combination; conclusions arrived at are that boiler drums affording greater security against rupture were those forged in single piece without any seams.

BOILERS

Blowdown. Chart Calculates Proper Boiler Blowdown, C. K. Jackson. Power, vol. 64, no. 16, Oct. 19, 1926, p. 582, 1 fig. Presents chart giving blowdown required to maintain concentration of 500 grains per gallon.

Developments. Boilers, Superheaters and Economizers. Nat. Elec. Light Assn.—Report, no. 256-11, Apr. 1926, 60 pp., 61 figs. Data on operation at Edgar Station, Hudson Avenue Station, Chester Station of Phila. Elec. Co., and Hell Gate Station; radiant-superheater installations; statement by Uniform Boiler Law Society.

German Regulations. The New Specifications for Stationary Boilers (Die neuen Werkstoffvorschriften und Bauvorschriften fur Landdampfkessel). Zeit. des Bayerischen Revisions-Vereins, vol. 30, no. 15, Aug. 15, 1926, pp. 181-185. New specifications for materials and construction adopted by German Steam Boiler Committee on June 18, 1926; reasons for adoption of new code.

Inspection. Uniform Examinations for Boiler Inspectors, C. D. Thomas. Boiler Maker, vol. 26, no. 9, Sept. 1926, pp. 268-269. Discussion of necessity for uniform inspections and reports to provide for acceptance of boilers in all boiler-code States.

Locomotive. See LOCOMOTIVE BOILERS.

Scale Prevention. The Prevention of the Formation of Boiler Scale. Engineering, vol. 122, no. 3168, Oct. 1, 1926, pp. 415-416, 5 figs. Water-cooled type of apparatus known as filtrator, which is now being used to prevent formation of boiler scale for removal of old deposits; processes consist in introducing water-soluble constituent of linseed into water which is fed into boiler, in such a way that no oil enters with it; with new modification, old trouble has been entirely eliminated; details of other modifications.

Waste-Heat. The Economy of Waste Heat Recovery, C. M. Walker. Gas Age-Rec., vol. 58, no. 14, Oct. 2, 1926, pp. 457-458, 2 figs. Installation by West Gas Improvement Co. of two Kirke waste-heat boilers at plant of Springfield Gas Light Co., which is example of what may be accomplished in way of utilizing heat previously wasted.

Water-Tube. See BOILERS, WATER-TUBE.

BOILERS, WATER-TUBE

Test Code. A Contribution to the Test Code of Water Tube Boilers, K. Kumabe. Soc. of Mech. Engrs. (Japan)—Jl., vol. 29, no. 112, Aug. 1926, pp. 474-480, 2 figs. In evaporation test of boilers, quantity of heat absorbed by furnace wall during heating period is very large compared with that after thermal stationary state is reached; author proposes to establish rule on preliminary firing period for such cases to limit error of result within certain range, and formulas for calculation are given. (In English.)

BORING MACHINES

Horizontal. Horizontal Boring Machines. Times Trade & Eng. Supp., vol. 18, no. 427, Sept. 11, 1926, p. 587. Modern designs; lathe-bed type; base-plate design; comparison of types; varied mechanisms.

BRAKING

Electric. Electric Braking, W. Wilson. Engineering, vol. 122, no. 3169, Oct. 8, 1926, pp. 435-437, 13 figs. Requirements of ideal electrically applied brake; solenoid braking; plugging; regenerative braking.

BRASS

Exudations. Exudations on Brass and Bronze, W. B. Price and A. J. Phillips. Am. Inst. Min. & Met. Engrs.—Trans. no. 1586-E, for mtg. Sept. 1926, 9 pp., 6 figs. Calls attention to phenomena which authors have encountered; protuberances on admiralty brass, bronze and on leaded brass; theory of inverse segregation.

Muntz Metal. Standardization of Microscopic Examinations of Muntz Metal Alloys, R. S. Pratt. Min. & Met., vol. 7, no. 237, Sept. 1926, pp. 374-375, 5 figs. Presents sketches adopted in preference to photomicrographs in laboratory of Bridgeport Brass Co. where it was felt that they could be more conveniently made to present exact type of structure desired.

BRASS FOUNDRIES

Developments. Controlling Quality in a Brass Foundry, R. Micks. Can. Foundryman, vol. 17, no. 9, Sept. 1926, pp. 19-21, 4 figs. Recent expansion in automotive, radio, vacuum-cleaner and electrical industries seems to assure development of brass foundry in Canada; equipment and methods of Sully Brass Foundry, Toronto.

BRONZES

Commonly Used. Bronzes in Common Usage, E. G. Jarvis. Brass World, vol. 22, no. 9, Sept. 1926, pp. 285-287. Formulas for preparing some of popular mixtures; effects of silicon, manganese, nickel, and phosphorus.

Heat Treatment. Heat Treatment Improves Bronzes, N. K. B. Patch. Iron Age, vol. 118, no. 13, Sept. 23, 1926, pp. 841-842, 2 figs. Modern methods for control of crystal structure in castings; effect on aluminum bronze.

C

CABLES, HOISTING

Care of. Lessons from a Hoisting Accident, L. Balliet. Eng. & Min. Jl., vol. 122, no. 16, Oct. 16, 1926, pp. 614-615. Broken cable caused little damage, thanks to counterweight; virtues of efficient rope lubrication.

CAMS

Circular-Arc. Graphical Analysis of Circular-Arc Cams, G. L. Guillet. Am. Mach., vol. 65, no. 17, Oct. 21, 1926, pp. 671-674, 8 figs. By means of graphical method of analysis, based upon equivalent link mechanisms, velocity and acceleration curves can be produced directly; Klein's construction.

CARS, FREIGHT

Repairing. Efficient Spot System of Car Repairs, A. H. Keys. Ry. Rev., vol. 79, no. 13, Sept. 25, 1926, pp. 467-470, 18 figs. Scheduled operations and unit gangs applied to heavy repairs on B. & O.

CAST IRON

Elasticity. Elasticity of Cast Iron at Ordinary and Elevated Temperatures, I. Sugimura. Soc. of Mech. Engrs. (Japan)—Jl., vol. 29, no. 112, Aug. 1926, pp. 437-473, 15 figs. For measurement of elasticity, newly designed extensometer was employed; study was undertaken to obtain quantitative elucidation on casting stress phenomena; casting stresses are those stresses induced in metal on account of its being cast, corresponding to "Gusspannungen" in German. (In English.)

Fatigue Tests. Fatigue Tests of Cast Iron, C. H. Bulleid. Engineering, vol. 122, no. 3168, Oct. 1, 1926, pp. 429-430, 4 figs. Results of tests made with special type of Wöhler reversed bending machine; it is shown that for so variable material as cast iron, conclusions from tests on one sample must be made with due caution.

Graphite in. The Comparison of the Size and Distribution of Graphite in Cast Iron. Foundry Trade Jl., vol. 34, no. 526, Sept. 16, 1926, p. 237. For general purposes most satisfactory method of comparing size and distribution of graphite in different specimens is use of comparative microstructures carefully prepared under comparative and standard conditions.

Growth. The Effects of Various Alloys on the Growth of Gray Iron Under Repeated Heatings, R. R. Kennedy and G. J. Oswald. Am. Foundrymen's Assn.—Advance Paper, no. 25, for mtg. Sept. 27-Oct. 1, 1926, 11 pp., 5 figs. Work undertaken with idea of developing gray iron having slow rate of growth under repeated heatings above critical range, and which could be reproduced by addition of various alloys to gray iron in ladle.

High-Duty. Progress in the Production of High-Duty Cast Iron, E. Piwowarsky. Am. Foundrymen's Assn.—Advance Paper, no. 23, for mtg. Sept. 27-Oct. 1, 1926, 68 pp., 29 figs. Reviews development of quality of gray cast iron in Germany; low melting temperatures vs. superheating; theories developed by science of crystallization; conclusions drawn from investigation of heated mold sections; relation between chemical composition and superheating and melting temperatures and contraction; theories based on formation of graphite above critical temperature; process for producing high-grade cast iron; conclusions drawn from dilatometer and growth tests; relation of graphite size and growth; effect of heating in oil and cooling in liquid air; effect of superheated steam.

Manganese, Desulphurizing Action of. Desulfurizing Action of Manganese in Iron, C. H. Herty, Jr., and J. M. Gaines, Jr. Am. Inst. Min. & Met. Engrs.—Trans., no. 1597-C, for mtg. Oct. 1926, 6 pp., 1 fig. In order to ascertain extent of and factors controlling elimination in ladle, several casts were sampled carefully at blast furnace and again when ladles were being emptied, either at mixer, open hearth or foundry; effect of temperature and time; percentage elimination of sulphur; conclusions.

Nickel Additions. Improving Gray Cast Iron with Nickel. Int. Nickel Co.—Bul., no. 8, 11 pp., 5 figs. Describes various useful effects of nickel additions to gray iron and suggests ways in which they can be and are used today by iron foundries in meeting many problems; gives list of castings for which nickel additions are recommended and are being successfully used.

Phosphorus, Influence of. The Influence of Phosphorus on Cast Iron, J. T. MacKenzie. Am. Foundrymen's Assn.—Advance Paper, no. 16, for mtg. Sept. 27-Oct. 1, 1926, 23 pp., 6 figs. Analysis, bending curves, drop test and Brinell hardness test on large numbers of irons cast in 2 by 1 by 24-in. bars; phosphorus is shown to lower strength and resilience, to increase Brinell hardness, and to stiffen bar slightly; in some cases, phosphorus, by promoting fluidity and hence soundness of casting, actually helps to make stronger casting.

Piston Rings. Cast Iron for Piston Rings (Neue Material-Untersuchungen uber Kolbenringguss), N. Stern. Motorwagen, vol. 29, no. 21, July 31, 1926, pp. 479-487, 32 figs. Points out that piston rings demand cast iron of exceptionally high qualities; good cast iron should be pearlitic in structure, but it is equally important that graphite should be finely subdivided and not present in large flakes, which can be effected by proper cooling velocity; directions for high-grade piston-ring cast iron are: low total carbon plus silicon percentage; fine subdivision of graphite; pearlitic matrix; high manganese percentage; phosphorus percentage not over 0.3 per cent; sulphur percentage not over 0.05 per cent; Brinell hardness of 165 to 185. See brief translated abstract in Automotive Abstracts, vol. 4, no. 9, Sept. 20, 1926, p. 281.

Shearing Test. A Shearing Test for Gray Cast Iron, G. K. Elliott. Am. Foundrymen's Assn.—Advance Paper, no. 13, for mtg. Sept. 27-Oct. 1, 1926, 13 pp., 6 figs. Use of Fremont machine for testing cast iron; tests of bars and flanged pipe fittings; test results secured by use of Fremont machine are compared with usual transverse and tensile test results; modification of machine was constructed to give double-end shearing and to overcome disadvantages of original apparatus.

Strength and Thickness. The Strength of Cast Iron in Relation to Its Thickness, W. H. Rother and V. Mazurie. Am. Foundrymen's Assn.—Preprint no. 31, for mtg. Sept. 27-Oct. 1, 1926, 21 pp., 6 figs. Cast-iron beams of various thicknesses do not follow regular beam formulas as set down for rolled steel; investigation to determine just how cast iron varies with thickness; it appears that decrease in strength tends to follow silicon content as high-silicon irons tend to show greater decrease than low-silicon irons containing steel; in practically all properties semi-steel proved best.

Testing. Testing Cast Iron, C. H. Bulleid. Foundry Trade Jl., vol. 34, no. 524, Sept. 2, 1926, p. 210. Describes work done by author. (Abstract.) Paper read before Brit. Assn.

Testing Cast Iron, A. E. Le Thomas. Am. Foundrymen's Assn.—Advance Paper, no. 34, for mtg. Sept. 27-Oct. 1, 1926, 53 pp., 13 figs. Observations made in course of several years and in some of larger foundries regarding application of those methods which have been retained by Association Technique de Fonderie de France; economic justification of tests; reasons governing choice of methods of testing; properties of high-resistance cast iron; examination of testing methods; shearing, compression, static bending, ball and tensile tests; micrographic examination and chemical analysis; relation between results given by various methods of testing machine castings; bases of specification for machine castings. Bibliography.

Tinning. The Tinning of Gray Cast Iron (Das Versinnen von Grauguss), Marnach. Giesserei, vol. 13, no. 37, Sept. 11, 1926, p. 691. Properties and occurrence of tin; methods employed in coating gray iron with another metal before tinning, because gray cast iron, due to its graphite content, has no metallically pure surface, on which coating metal can be applied.

CASTING

Centrifugal. Centrifugal Tube Casting in Hot Molds, L. Cammen. Am. Foundrymen's Assn.—Preprint no. 36, for mtg. Sept. 27-Oct. 1, 1926, 7 pp. Materials for heated molds; experiments to develop material; protecting mold surface from solvent action of hot steel; temperature of hot molds.

Some Notes on the Development of the Centrifugal Casting Process in Great Britain and Europe, J. E. Hurst. Am. Foundrymen's Assn.—Advance Paper, no. 28, for mtg. Sept. 27-Oct. 1, 1926, 15 pp., 2 figs. Early developments of process in Great Britain from year 1809, with special reference to work of Joseph Whitley; application of process to production of pipes in Great Britain and Belgium by Lavaud system, and development of other centrifugal pipe casting processes; Hurst-Ball system which is being developed and has

already been used to produce 35-in. diameter standard pipes; deals with special development of process as applied to production of castings for cylinder liner and piston rings; development of process for production of castings in steel, non-ferrous alloys and its application to lining of pipes with concrete and other materials. See also Metal Industry (Lond.), vol. 29, nos. 14 and 15, Oct. 1 and 8, 1926, pp. 319–321 and 345–347, 2 figs.; and Foundry Trade Jl., vol. 34, no. 528, Sept. 30, 1926, pp. 290–292.

CENTRAL STATIONS

Foundations. Building Foundation of a 1,000,000 Horsepower Generating Station, J. S. Kerins. Eng. World, vol. 29, no. 3, Sept. 1926, pp. 143–146, 5 figs. Construction details of foundation of station being erected by New York Edison Co. on East River at foot of 14th Street; building has average height of about 130 ft. with steel smoke stacks towering additional 240 ft. above roof; one of chief problems encountered was designing system for distributing concrete which would satisfactorily meet unusual requirements placed upon it; system of aerial distribution from mixing plant entirely outside area of excavation was finally adopted; details of excavation, etc.

France. Characteristics of Modern Central Stations (Les caractéristiques des grandes stations centrales à vapeur récentes ou en cours d'achèvement), A. dé Casanova. Génie Civil, vol. 89, no. 5, July 31, 1926, pp. 104–105; and translated abstract in Eng. & Boiler House Rev., vol. 40, no. 3, Sept. 1926, pp. 142 and 144. In most cases large central stations recently completed or in course of construction are near "center of gravity" of their distribution systems, but in increasing number of cases, stations are far removed from load center of system, to which they are connected by extra high-tension supply lines at pressures up to 132,000 volts or even higher; boiler units have heating surface of 15,000 to 32,500 sq. ft.; steam pressure of 400 lb. per sq. in. is common and may even be regarded as minimum; general trend is toward use of smaller tubes, with forged instead of riveted drums; air heaters are being used to cool gases before they enter smoke stack; attention is being paid to utilization of radiant heat; thermal efficiencies exceed 80 per cent in many plants.

High Pressures and Temperatures. Use of High Steam Pressures and Temperatures in Central Stations, E. Rauber. Power, vol. 64, no. 17, Oct. 26, 1926, p. 634. Problem of steam pressures; practical developments in high-pressure steam generation. Abstract translated from paper presented at Rome convention of Int. Union of Producers & Distributors of Electrical Energy.

Hunlock Creek, Pa. Hunlock Creek, Penna., Power Station. Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, pp. 1040–1045, 4 figs. Initial capactiy of new station was fixed at 20,000 kw. to meet rate of growth in load with plans for future development to 190,000 kw.; generators connected direct to transformers; turbine bled for feedwater heating; make-up water evaporated.

Hydraulic vs. Steam. Economic Relations Between Hydraulic and Steam Generation of Electric Power (Die wirtschaftlichen Beziehungen zwischen der elektrischen Energie, die hydraulisch erzeugt wird und solcher, die man thermisch erzeugt, Bedingungen, unter denen beide systeme vorteilhaft zusammenarbeiten können), F. Krieger. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 57, 23 pp., 1 fig. Deals with economic conditions with regard to steam-electric plants and isolated hydroelectric plants, and discusses economic relations and collective working of various plants; investigations are limited to large power stations; conditions prevailing at Bayernwerk, where power is generated by low-pressure hydroelectric plants, steam and high-pressure reservoir stations, working in parallel.

Pulverized-Coal-Burning. Pulverized Fuel at Ashley Street Plant, E. H. Tenney. Elec. Light & Power, vol. 4, no. 10, Oct. 1926, pp. 21–23, 6 figs. Unit type of pulverizer was chosen largely because physical arrangement of equipment already operating was not suited to application of central pulverizing system without unjustified cost; pulverizer on all boilers is Simplex mill of Furnace Engineering Co., rated at 8000 lb. per hr.; problems arising in connection with burners and furnace arrangement.

Sweden. Turbine and Plant Efficiencies, R. H. Andrews. Power, vol. 64, no. 15, Oct. 12, 1926, p. 560, 2 figs. Presents efficiency curves obtained with Kaplan and propeller-type turbines in low-head plant at Lilla Edet in Sweden.

Tecumseh, Kansas. Tecumseh Serves Topeka District. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1088–1094, 7 figs. New plant of Kansas Power & Light Co. is designed for ultimate capacity of 125,000 kva.; at present it has installed capacity of 15,000 kva. in two units with room for third unit of 20,000 kva.; steam is generated at 375-lb. pressure with 250 deg. superheat, house turbine and motor-driven auxiliaries are used; vertical condensers installed.

CHIMNEYS

Streamline. Tests on Stream-Line Stacks, E. Prat and L. C. Whiton, Jr. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1101–1105, 8 figs. Determination of air flow, power used for induced draft and efficiency.

COAL

Carbonization. Low-Temperature Carbonization, D. Brownlie. Combustion, vol. 14, nos. 4, 5, 6, vol. 15, nos. 1, 2, 3 and 4, Apr. May, June, July, Aug., Sept., and Oct. 1926, pp. 253–259, 321–325, 385–391, 38–40, 108–110, 169–172, and 237–241, 7 figs. Apr.: Predrying of raw fuels before combustion carbonization, or gasification; low-temperature carbonization in conjunction with mechanically fired furnaces. May: Julius Pintsch process; work of Merz and McLellan, Ltd.; Pluto-stoker process. June: carborite dual coal carbonization. July: Low-temperature carbonization in conjunction with pulverized-fuel firing; advantages and disadvantages. Aug.: McEwen-Runge process. Sept.: Midland Coal Products Co. process. Oct.: Staveley Coal & Iron Co. or Markham processes.

The "Midland Coal Products" Process, D. Brownlie. Gas Engr., vol. 42, no. 605, Sept. 1926, pp. 186–187, 2 figs. Low-temperature carbonization and partial gasification of briquetted small non-coking coal.

Combustion. Coal Testing and Combustion Calculations, F. Dransfield. Elec. Rev., vol. 99, no. 2546, Sept. 10, 1926, pp. 413–415, 4 figs. Attempt is made to correlate number of coal tests with view to either (1) obtaining flue-gas loss directly from proximate analysis, or (2) determining carbon content more exactly from proximate analysis so that losses can be calculated by existing methods.

Oxidation. An Investigation of the Behaviour of Solid Fuels During Oxidation, B. Moore and F. S. Sinnatt. Fuel, vol. 5, no. 9, Sept. 1926, pp. 377–380, 4 figs. Method which indicates marked alteration in ignition properties of coal during storage; results show that modification leads to diminution of tendency of coal to ignite.

Pulverized. See PULVERIZED COAL.

COAL HANDLING

Bridges, Protection of. Wind Measurement and the Protection of Coal and Ore Bridges, C. Stenbol. Eng. Jl., vol. 9, no. 10, Oct. 1926, pp. 425–429, 2 figs. Discussion of existing wind-recording instruments and special designs for use as protective measure on coal and ore bridges and study of wind action on such bridges.

Towers. A Four-Ton Coal-Handling Tower, M. R. Summer. Elec. World, vol. 88, no. 13, Sept. 25, 1926, pp. 653–654, 6 figs. Capacity, 400 tons per hour; hopper capacity, 125 tons; belt conveyor to bunkers; barge shifter used; construction details and costs.

Unloaders. 2000 Ton Coal Handling Plant and Automatic Weighing Machines. Eng. & Boiler House Rev., vol. 40, no. 3, Sept. 1926, pp. 128–132, 2 figs. Largest coal-unloading plant in Europe installed at Beckton Gas Works.

COKE

Central Heating with. Coke Economy in Central Heating, Gunther. Gas World, vol. 85, no. 2198, Sept. 18, 1926, p. 243. For central heating, gas coke is to be preferred, but tests of this are necessary; two questions must be considered, namely, how is firing to be tended, and what is meant by economic heating.

CONDENSERS, STEAM

Tubes. Investigation of Strongly Corroded Brass Condenser Tubes (Untersuchungen von Messingkondensatorrohren mit starker Korrosion), M. Schwarz. Korrosion u. Metallschutz, vol. 2, no. 1, Jan. 1926, pp. 8–17, 17 figs. Examination of tubes from two power plants showed basic zinc carbonate in corroded spots and experiments showed that cooling water attacked beta mixed crystals of brass.

CONVEYORS

Automobile Industry. Conveyors Used in the Automotive Industry, C. A. Brock. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 343–350, 18 figs. Describes various types of conveyors serviceable to automotive industry; principles of selection and design; drawings and photographs of some of latest developments.

Transportation by Conveyor, P. Phelps and N. H. Preble. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 413–421, 21 figs. Explains how mechanical handling systems can be utilized for transportation or assembly or both combined in all specified procedures in production of modern automobile; various forms of conveyors and their application to obviate handling difficulties, to increase speed of transporting parts and to augment rapidity of assembly; reductions in cost due to conveyor installations; how difficulties were overcome.

Factories. Conveyors Slash Handling Costs, G. Prifold. Factory, vol. 37, no. 4, Oct. 1926, pp. 618–620, 5 figs. Savings which conveyors are making on handling costs are forcefully emphasized by $68,000 a year combined savings of three companies.

Natural-Frequency. Natural Frequency Conveyors. Machy. (Lond.), vol. 28, no. 723, Aug. 19, 1926, pp. 573–575, 7 figs. Describes principle on which vibrating conveyors, which have been subject to extensive experiments in Germany, works and remarkable results obtained with conveyors of simple construction; this type of conveyor should not be confused with shaker type, which oscillates comparatively slowly, whereas this conveyor vibrates 950 times a minute, its movement being invisible to observer; influence of nature of material on action of conveyor. Information based on article by H. Heymann in Zeit. des Vereines deutscher Ingenieure.

COOLING PONDS

Spray. Costs of a Spray-Pond Cooling System, R. H. Emerick. Power, vol. 64, no. 15, Oct. 12, 1926, pp. 559, 2 figs. Describes spray-pond cooling-water system.

CORE OVENS

Electric. Core Baking with Electric Heat. Nat. Elec. Light Assn.—Report, no. 256–288, Aug. 1926, 6 pp., 5 figs. Core sands and binders; strength of cores; preparation of core mixtures; drying core; electric core baking; advantages of electrically heated core ovens.

Oil-Fired. Baking of Radiator Cores in Oil Fired Ovens, I. S. Wishoski. Fuels & Furnaces, vol. 4, no. 9, Sept. 1926, pp. 1077–1079 and 1086, 3 figs. Car-type ovens arranged in two batteries of five ovens each are individually heated by single oil burners firing into long combustion chambers beneath ovens; very uniformly baked cores are produced and good fuel economy is obtained.

CORES

Binders for. A Standard Sand for Use in Testing Core Binders, H. L. Campbell. Am. Foundrymen's Assn.—Preprint no. 24, for mtg. Sept. 27–Oct. 1926, 7 pp., 1 fig. Establishes specification for sand which would be recommended for general use in testing core binders; effect of grain size on dry bond and permeability was determined; from test results it was concluded that sand for testing purposes should be limited to one sieve size which, according to writer's opinion, is that sand which passes 60-mesh sieve and is retained on 70-mesh sieve.

Methods for Determining the Properties of Cores Made with Cereal Binders, H. L. Campbell. Am. Foundrymen's Assn.—Advance Paper, no. 30, for mtg. Sept. 27–Oct. 1, 1926, 10 pp., 2 figs. Methods for measuring green bond of core sand mixtures and permeability of dry-sand cores; these properties, as well as dry bond strength of cores, should be obtained when comparing relative values of cereal binders or establishing most economical practice in use of any of cereal binders.

Core Oils. Some Properties of Core Oils, C. A. Hansen. Am. Foundrymen's Assn.—Preprint, no. 9, for mtg. Sept. 27–Oct. 1, 1926, 32 pp., 1 fig. Study of five commercially pure vegetable oils in respect to maximum core strength developed with varying oil ratios, in respect to baking time required to attain maximum strength of varying temperatures, and to effect of moisture on strength of baked cores; effect of various driers, various diluents, varying proportions of resin, boiling oils and oil mixtures.

Supports. Core Supports in Large Castings, I. Lamoreux. Am. Foundrymen's Assn.—Preprint no. 20, for mtg. Sept. 27–Oct. 1, 1926, 7 pp., 8 figs By examining reactions of core support during casting, author tries to evolve instructions for founder.

CRANES

Railway Storage-Battery. Storage-Battery Rail Cranes (Akkumulator-Kranfahrzeuge), W. Rodiger. Fördertechnik u. Frachtverkehr, vol. 19, nos. 18 and 19, Sept. 3 and 17, 1926, pp. 269–271 and 291–293, 12 figs. Describes various types of cranes traveling on railways and street-railway tracks, and gives dimensions, capacity, motor efficiency, size of batteries, speed and radius of action.

CRUCIBLES

Prolonging Life of. How to Extend Crucible Life. Foundry, vol. 54, no. 18, Sept. 15, 1926, pp. 745 and 754, 2 figs. Attention is directed to faulty practice resulting in rapid destruction of crucibles; detailed instructions given for simple annealing oven.

CUPOLAS

Coke-Charge Calculation. Calculating a Cupola Coke Charge with Reference to Its Diameter (Die Bestimmung des Satzgewichtes in Abhängigkeit vom Schachtdurchmesser), T. Kleinsorge. Giesserei, vol. 13, no. 32, Aug. 7, 1926, pp. 561–562, 3 figs.; also translated abstract in Foundry Trade Jl., vol. 34, no. 526, Sept. 16, 1926, p. 246, 1 fig. Author measured height of coke charge of great number of cupolas and determined CO_2 and CO content of gas current; he found most suitable height to be 0.59 ft.; weight of coke charge is then calculated according to given formula; height of coke per unit volume largely depends upon diameter of shaft; results of experiments are given in graphic and tabular form.

Hot-Blast. Hot Blast Cupola, P. Dwyer. Foundry, vol. 54, no. 18, Sept. 15, 1926, pp. 729–735 and 754, 14 figs. Preheated air effects economy in continuous and stringent service at foundry of Griffin Wheel Co., Chicago; heated and unconsumed gas is drawn from cupola through ring of tuyeres located 2 ft. below charging door level; this gas is burned with addition of little free air under insulated steel-plate chamber containing number of vertical cast-iron tubes; flame travels through these tubes and heats cold blast which enters through suitable opening and circulates among tubes.

Melting Steel Charges. Melting All Steel Charges in a Cupola Furnace, T. F. Jennings. Am. Foundrymen's Assn.—Advance Paper, no. 6, for mtg. Sept. 27–Oct. 1, 1926, 8 pp. Necessity of disposing of accumulation of 12,000 tons miscellaneous steel scrap forced author into developing method for melting entire heats of steel in cupola; heats of 30 tons are poured daily 7 days a week without any more trouble than is experienced in running off usual gray-iron heats of same tonnage. See also Foundry, vol. 54, no. 19, Oct. 1, 1926, pp. 779–780 and 787.

Melting Zone of. A Study of Iron Melted in the Cupola, R. E. Wendt and J. P. Walsted. Am. Foundrymen's Assn.—Advance Paper, no. 4, for mtg. Sept. 27–Oct. 1, 1926, 11 pp., 5 figs. Discusses question of melting zone of cupola and shows that all melting does not take place in what is commonly known as melting zone; experimental data secured in foundry which shows variation in analyses of iron in different parts of same heat; iron in cupola melts much higher up in stack than is usually considered to be true and cupola iron may be made more uniform by changing method of charging usually followed by most foundries.

Volume Measurement. The Pitot Tube and the Measurement of Cupola Volume, J. F. Francis. Metal Industry (Lond.), vol. 29, no. 11, Sept. 10, 1926, pp. 247–248, 1 fig. Discusses Pitot-static tube method of measuring blast volume, and points out some of factors tending to cause inaccurate readings and how best to overcome them.

CUTTING METALS

Oxygen Purity and Temperatures. Relative

Effect of Oxygen Purity and Temperature in Metal Cutting, F. P. Wilson, Jr. Gen. Elec. Rev., vol. 29, no. 10, Oct. 1926, pp. 722–727, 10 figs. Difference between cutting efficiency of 98.5 and 99.5 pure oxygen controversial; comparative tests show definite savings of much greater magnitude by preheating oxygen; maximum economy obtainable by using cheaper gas with preheat; preheat also facilitates quick starting, and eliminates moisture troubles and hardening face of cut.

D

DIES

Die-Sinking Machines. Die-Sinking Machines (Graviermaschinen), Wimplinger. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 37, Sept. 11, 1926, pp. 1231–1232, 9 figs. Details of die-sinking machines and methods of application; these machines are used principally in optical, mechanical and electrical industries, in clock-manufacturing plants, and in production of typewriters, calculating machines, etc.; especially adapted to mass production.

Expanding. Dies for Expanding Pressed Shapes, E. Heller. Machy. (Lond.), vol. 28, no. 726, Sept. 9, 1926, pp. 694–696, 3 figs. Construction of expanding die; operation of die; angle of expanding cone; die with rubber expanding member; replacement of rubber member.

DIESEL ENGINES

Busch-Sulzer. Big Busch-Sulzer Engines Completing. Motorship, vol. 11, no. 10, Oct. 1926, pp. 777–780, 9 figs. Six-cylinder 3000-b.hp. units constructed for Shipping Board conversions.

Characteristics and Difficulties. Fundamental Diesel Characteristics Important, J. J. McDougall. Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, pp. 1058–1059, 2 figs. Points out that poor maintenance and overloads are responsible for many Diesel-engine difficulties.

Fairbanks, Morse. Fairbanks, Morse Build Larger Diesels. Motorship, vol. 11, no. 10, Oct. 1926, pp. 759–763, 13 figs. Company is now constructing Diesel engines in ratings of 480, 600, and 720 hp.; they are 2-cycle, port-scavenging, airless-injection type. See also descriptions in Mar. News, vol. 13, no. 5, Oct. 1926, pp. 50–51, 2 figs.; and Oil Engine Power, vol. 4, no. 10, Oct. 1926, pp. 608–615, 14 figs.

Large, Quantity Production of. Quantity Production of Larger Diesels Under Way. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1107–1109, 4 figs. New units of 480, 600, and 720 hp. offered by Fairbanks, Morse & Co. to meet demands of industry for quantity production of larger engines.

M.A.N. The 15,000 b.h.p. Diesel Engine, M.A.N. System, Built by Blohm & Voss for the Hamburg Electricity Works, M. W. Laudahn. Eng. Progress, vol. 7, no. 8, Aug. 1926, pp. 201–206, 12 figs. Plant of Neuhof power station, with special reference to Diesel prime mover. See also description in Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, pp. 1056–1058, 4 figs.

Winton. Latest Winton Diesel is 800 hp. Unit. Motorship, vol. 11, no. 10, Oct. 1926, pp. 768–770, 6 figs. New model specially designed for yachts, towboats and ferryboats; develops 800 b.hp. at 300 r.p.m.; it has six cylinders and works on 4-cycle air-injection principle.

DRILLING MACHINES

Automobile-Frame. 50-Spindle Drilling Machine for Motor-Car Frames. Machy. (Lond.), vol. 28, no. 723, Aug. 19, 1926, pp. 584–585, 2 figs. Built by F. Pollard & Co. for use on Morris-Cowley frames; purpose of machine is to drill simultaneously all holes required in side of frame.

Heavy-Duty Gang. Heavy Duty Gang-Drilling Machines. Engineering, vol. 122, no. 3167, Sept. 24, 1926, pp. 380–381, 2 figs. Four-spindle and three-spindle machines constructed by J. Archdale & Co., Birmingham, Eng.

Multiple-Spindle. Rapid Drilling and Tapping on Multiple-Spindle Machines. Machy. (Lond.), vol. 28, no. 726, Sept. 9, 1926, pp. 681–683, 6 figs. Drilling connecting rods; washing-machine parts, holes at angles, etc.; special jigs and fixtures, and machines on which they are used, made by Moline Tool Co., U. S. A.

Radial. New Radial Has Distinctive Features. Iron Age, vol. 118, no. 14, Sept. 30, 1926, pp. 929–930, 2 figs. Radial drill developed by Cincinnati Bickford Tool Co. and known as Super-Service radial; 36 speeds, 18 feeds and power rapid traverse are incorporated in head; control centralized, oiling is automatic; roller bearings employed.

E

ELECTRIC DRIVE

Individual and Group. Determining Economy of Individual Drive, F. H. Penney. Can. Machy., vol. 36, no. 13, Sept. 23, 1926, pp. 17 and 34. Although there is decided tendency toward individual motor drive for all tools in plant, author points out that group drive with its much smaller installed motor capacity is sometimes preferable.

Group and Individual Drive for Industrial Machinery, L. H. Hopkins. Indus. Mgmt. (N. Y.), vol. 72, no. 4, Oct. 1926, pp. 211–219, 3 figs. Factors to be studied in determining selection.

ELECTRIC FURNACES

Annealing. Annealing Iron and Steel in the Electric Furnace. Nat. Elec. Light Assn.—Report, no. 256–281, Aug. 1926, 5 pp., 4 figs. Electric furnace gives uniform high quality of product, minimizes labor of attendance, reduces losses, gives greater productive capacity without increase of labor, saves cost of annealing boxes and energy for heating same, and contributes greatly to reduction and elimination of labor turnover.

Annealing Aluminum in. Annealing Aluminum in the Electric Furnace. Nat. Elec. Light Assn.—Report, no. 256–283, Aug. 1926, 3 pp., 2 figs. Electric furnace produces heat-treating method in which heating may be constant, physical properties kept uniform and all blistering may be prevented; no combustion products are present and therefore no impurities are introduced into metal; installation data.

Brass. Annealing Brass and Copper in the Electric Furnace. Nat. Elec. Light Assn.—Report, no. 256–291, Aug. 1926, 3 pp., 3 figs. Electric furnace for brass annealing has removed all chance because of automatic temperature control, not only of muffle temperature, but also of temperature of charge itself; results of installation in Connecticut have proved that electric brass annealing is more economical than annealing with wood fuel; results of electric-furnace installation at Rome, N. Y.

Melting Brass in the Electric Furnace. Nat. Elec. Light Assn.—Report no. 256–287, Aug. 1926, 6 pp., 3 figs. Summary of disadvantages of fuel-fired furnaces and advantages of electric furnaces; induction, direct-arc, indirect-arc, indirect-resistance, combinations of previous principles, and high-frequency furnaces.

Melting. Melting Steel and Gray Iron in the Electric Furnace. Nat. Elec. Light Assn.—Report, no. 256–284, Aug. 1926, 6 pp., 4 figs. Discusses advantages of electric furnaces for this purpose.

Tempering. Rotary Tempering Furnace for Gears. Iron Age, vol. 118, no. 15, Oct. 7, 1926, pp. 1001–1002, 2 figs. Continuous electric, rotary-type, oil-tempering furnace with automatic control installed in plant of Warner Gear Co., Muncie, Ind.; it is used for heat treating gears and is said to be first continuous oil-drawing furnace ever built; designed by Strong, Carlisle & Hammond Co., Cleveland.

Thermal Insulation. Thermal Insulation of Electric Furnaces, M. L. Hartmann and O. B. Westmont. Am. Electrochem. Soc.—Advance Paper, no. 12, for mtg. Oct. 7–9, 1926, pp. 155–176, 15 figs. Gives thermal conductivities of fused alumina, fused magnesia, fireclay and high-temperature insulating refractory; mean specific heat curves for these refractories are also given; suggests possibilities of energy conservation in electric furnaces by properly designed composite walls.

ELECTRIC LOCOMOTIVES

Austria. Electrification of Austrian Federal Railway. Locomotives (Die Elektrifizierung der Osterreichischen Bundesbahnen-Lokomotiven), R. Lorenz. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 51, 13 pp., 9 figs. Data on different types employed; experiences made with all types were entirely satisfactory and difficulties which were apparent at first, had been entirely overcome.

Brazil. New Electric Locomotive for Brazil. Elecn., vol. 97, no. 2518, Sept. 3, 1926, pp. 262–263, 3 figs. Details of 100-ton locomotive completed by Metropolitan-Vickers Electrical Co. for passenger service on Paulista Railway of Brazil; most powerful equipment yet constructed in England.

Tractive Resistance. The Tractive Resistance of Electric Locomotives and Cars, W. J. Davis, Jr. Gen. Elec. Rev., vol. 29, no. 10, Oct. 1926, pp. 685–707, 13 figs. Source of data; train resistance classified; discussion of three main classes; formulas for total resistance; tables and charts.

Virginian Railway. Rigid Frames Feature Electric Locomotives for Virginian Railway, C. C. Whittaker. Elec. Ry. Jl., vol. 68, no. 12, Sept. 18, 1926, pp. 451–453, 4 figs. Layout of apparatus on these 11,000-volt, single-phase units dictated by adoption of solid framing instead of articulated type; several extremely heavy pieces had to be anchored to prevent shifting under severe strains incident to buffing shocks.

ELECTRIC WELDING

Butt. On Electric Butt Welding, T. Okamoto. Inst. Elec. Engrs. Japan—Jl., no. 457, Aug. 1926, pp. 885–898, 16 figs. Deals with butt welding of soft steel bars. (In Japanese, with brief English abstract.)

Gas Holders. Electric Welding Steel Gas Holders, G. T. Horton. Can Engr., vol. 51, no. 10, Sept. 7, 1926, pp. 277–279, 3 figs. Tendency towards heavier and more economical construction; welding various parts of gas-holders; advantages of spherical pressure containers for gas or oil. Paper presented at Can. Gas Assn.

Practical Advantages. Practical Electrical Welding, S. Halas. Elecn., vol. 97, no. 2522, Oct. 1, 1926, pp. 388–390, 6 figs. Workshop advantages; mass production and special types; localizing heat; space question.

ELECTRIC WELDING, ARC

Electrode Efficiency. Electrode Efficiency, P. L. Roberts. Welding Engr., vol. 11, no. 9, Sept. 1926, pp. 25–27. Result of tests made to determine amount of electrode usefully deposited by metallic arc.

Structural Steel. Arc Welds in Structural Steel, A. M. Candy and G. D. Fish. Welding Engr., vol. 11, no. 9, Sept. 1926, pp. 30–33, 7 figs. Tests show that ultimate strength of structural members can be obtained and special designs are needed.

EMPLOYEES' REPRESENTATION

Survey of. Survey of Employee Representation. Ry. Mech. Engr., vol. 100, no. 10, Oct. 1926, pp. 586–587. Discussion of books on improved supervision and better employee relations.

EMPLOYMENT MANAGEMENT

Efficiency Contests. Efficiency Contests Increase Production, J. A. Muir. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 255–256, 4 figs. Plan in use at Baltimore Works of General Electric Co. was adapted to suit plant conditions by collaboration of members of managerial staff of plant; it includes following points of review; workmanship, keeping of promises, economy, good housekeeping, attendance and punctuality and general deportment.

Evolution of. The Evolution of Personnel Management, W. J. Matherly. Indus. Mgmt. (N. Y.), vol. 72, no. 4, Oct. 1926, pp. 256–257. Beginning of factory system; twentieth-century methods; effects of World War and post-war reaction.

F

FATIGUE

Industrial. Industrial Fatigue, E. J. Kunze. Indus. Mgmt. (N. Y.), vol. 72, no. 4, Oct. 1926, pp. 233–235. Methods of increasing satisfaction of tasks; effect of fatigue on failure; physical surroundings; stimulus of high wage; personal pride and individuality, as against submergence as cog.

FERROALLOYS

Additions, Determining Weight of. Determining the Weight of Alloy Additions, R. S. Kerns. Blast Furnace & Steel Plant, vol. 14, no. 10, Oct. 1926, pp. 439–441, 1 fig. Author has prepared series of curves which make it possible to quickly determine amount of ferroalloy to be added to any weight of charge.

FLOW METERS

Electric. Electric Flow Meter Has Interesting Features, T. R. Harrison. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1130–1132, 3 figs. Manometer made by Brown Instrument Co., and its operation.

FLOW OF WATER

Illustrations. Hydrodynamic Display of the Swiss Technical High School at the International Exposition at Basel (Hydrodynamische Darstellungen der E. T. H. and der I. A. B. W. in Basel 1926), F. Prasil. Schweizerische Bauzeitung, vol. 88, nos. 11 and 12, Sept. 11 and 18, 1926, pp. 154–159 and 168–171, 26 figs. Snapshots taken at hydrodynamic laboratory illustrating flow round throttling valve at various velocities, laminar flow in guide wheels, formation of turbulent flow, Rankine's eddies. Development of turbine characteristics; comparative results.

FLUE-GAS ANALYSIS

Combustion Control by. Combustion Control Through Flue-Gas Analysis (Die Kontrolle der Verbrennung durch die Rauchgasanalyse), A. B. Helbig. Feuerungstechnik, vol. 14, no. 20, July 15, 1926, pp. 243–244. Shows how, through flue-gas analysis, influence of changes in combustion can be indicated in practice.

Sampling Lines to CO_2 Recorders. Successful Sampling Lines, C. C. Phelps. Power, vol. 64, no. 15, Oct. 12, 1926, pp. 546–548, 3 figs. Points out that slight changes in sampling line have eliminated 80 to 90 per cent of attention formerly required; brass or copper best for sampling lines, preventing galvanic action.

FLYING BOATS

Wings. Experimental Determination of Strength of Metal Wing, A. Klemin. Aviation, vol. 21, no. 15, Oct. 11, 1926, pp. 628–634, 11 figs. Wind-tunnel and static tests on wing of Edo metal flying boat.

FORGING

Furnaces. Economically Operated Forging Furnace, G. L. Davis. Ry. Mech. Engr., vol. 100, no. 10, Oct. 1926, pp. 632–633, 1 fig. Oil-fired adaptation of older type of down-draft, coal burning forge.

Presses. The Largest Steam-Hydraulic Forging-Press, W. J. Priestley. Min. & Met., vol. 7, no. 238, Oct. 1926, pp. 426–429, 5 figs. Notable war-time achievement described for first time; press used for forging armor, as well as bending and rectifying it, and forging ingots for large caliber guns.

FOUNDRIES

Automobile Plants. How New Equipment Helped Triple Output in an Auto Foundry, P. Dwyer. Foundry, vol. 54, nos. 11, 12 and 15, June 1, 15 and Aug. 1, 1926, pp. 418–422 and 444, 8 figs.; 464–468 and 478, and 596–600, 8 figs. Methods and equipment of gray-iron foundry of General Motors Corp. in Saginaw, Mich. June 1: Day and night shifts; general features; mold and sand conveyors. June 15: Ladle-handling devices; uniformity in machines; sand-handling equipment. Aug. 1: Making up charges; preliminary cleaning.

Secures High Production with Conveyor System, F. G. Steinebach. Foundry, vol. 54, no. 19, Oct. 1, 1926, pp. 760–765, 8 figs. Methods and equipment of Superior Foundry Co., Cleveland, O., which recently began manufacture of motor castings; molds are carried from molding machines to pouring department and then to shakeout; sand is carried from shakeout through reconditioning processes and to storage bins; all these transfers are handled on some form of conveyor.

Materials Handling. A 67 to 1 Material Handling Ratio. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 277–280. Large foundry studies processes, which, though efficiently planned, involve repeated handlings of vast weights.

Handling Materials in a Foundry, E. T. Bennington, Am. Foundrymen's Assn.—Preprint, no. 14, for mtg. Sept. 27–Oct 1, 1926, 10 pp.; also abstract in Am. Metal Market, vol. 33, no. 199, Oct. 16, 1926, pp. 24 and 28–29. Offers two suggestions as to how improvement can be brought about, first by so installing materials-handling machinery that handling operation will be eliminated or combined into one operation, and second, by increasing size of unit or production or increasing size of ladle, flask, and of load which is carried to cleaning room. See also Foundry Trade Jl., vol. 34, no. 528, Sept. 30, 1926, pp. 293–294.

Non-Ferrous. Temperature Determination in the Non-Ferrous Foundry. Am. Foundrymen's Assn.—Advance Paper, no. 8, for mtg. Sept. 27–Oct. 1, 1926, 24 pp., 4 figs. Symposium of papers as follows: Pyrometer Control in a Brass Foundry, A. S. Hall; Use of Pyrometers in the Casting of Non-Ferrous Metals, R. D. Bean; Thermo-Couple for Ladle Temperatures of Brass, A. A. Grubb, L. H. Marshall, and C. V. Nass; Visual Judgment of Non-Ferrous Metal Temperatures, R. R. Clark. See also Metal Industry (N. Y.), vol. 24, no. 10, Oct. 1926, pp. 409–416.

Temperature Control. Temperature Control. Am. Foundrymen's Assn.—Advance Paper, no. 15, for mtg. Sept. 27–Oct. 1, 1926. Contains following articles: Temperature Control in Aluminum Foundries, K. Marsh, pp. 2–29, 7 figs; Temperature Control in the Brass Foundry, H. M. St. John, pp. 30–36.

Wage Payments by Results. The Application of Payment by Results to the Foundry Industry, J. W. Kearsey. Foundry Trade Jl., vol. 34, nos. 521, 525, and 526, Aug. 12, Sept. 9 and 16, 1926, pp. 130–131 227–228, and 243–245. Reviews various classes of labor, included in personnel of foundry, in rotation. Aug. 12: Patternmaking. Sept. 9: Molding, rate fixing for machine and hand molding, core-making, and fettling. Sept. 16: Furnace attendants; laborers; supervisory staff; treatment of defective work; treatment of contingencies affecting output; preliminary trial of production methods.

FOUNDRY EQUIPMENT

Exhibition, Detroit. Show Greatest in History. Foundry, vol. 54, no. 20, Oct. 15, 1926, pp. 818–824 and 835, 9 figs. Features of exhibit; rapid progress being made toward complete mechanical operation of processes in foundry industry was well exemplified at exhibition which was greatest in history of American Foundrymen's Assn.

FRICTION GEARING

Load and Velocity. Load Ratio and Gliding Velocity of Friction Gears (Belastungsverhaltnis und Gleitgeschwindigkeit bei Reibungsgetrieben), W. Heyn. Zeit. für angewandte Mathematik u. Mechanik, vol. 6, no. 4, Aug. 1926, pp. 308–313, 4 figs. Author discusses determination of load ratio and gliding velocity and seeks to harmonize results obtained with published tests.

FUELS

Coal. See COAL; PULVERIZED COAL.

Coke. See COKE.

Locomotive Clinkers, Recovery From. Fuel Recovery from Locomotive Clinkers. Eng. Progress, vol. 7, no. 8, Aug. 1926, p. 212, 2 figs. Describes portable clinkers-dressing plant employed by German State Railways for recovery of about 20 per cent utilizable fuel.

Oil. See OIL FUEL.

Pulverized Coal. See PULVERIZED COAL.

Solid Smokeless. Conference on Solid Smokeless Fuel. Chem. & Industry, vol. 45, no. 35, Aug. 27, 1926, pp. 289T–295T and (discussion) 296T–301T. Summary of papers and discussion on this subject during 1925; requirements of solid smokeless fuel; present use of coke; ease of ignition and combustibility; dryness of coke; strength and compactness; coke, grading, etc.

FURNACES, GAS

Radiant-Heat. A Radiant-Heat Furnace. Gas Jl., vol. 175, no. 3302, Sept. 1, 1926, p. 474, 2 figs. Patented design was invented and applied by Wollers of Krupp Laboratories; its chief characteristics are (1) heating is entirely by radiation without flame formation, and consequently without disadvantages of flame contact with contents; (2) intimate admixture of gas and air (latter heated in recuperator) is effected in early stages.

FURNACES, INDUSTRIAL

Design. General Principles of Furnace Construction and Design, W. Trinks. Gas Age-Rec., vol. 58, nos. 13 and 14, Sept. 25 and Oct. 2, 1926, pp. 419–422 and 453–456, 16 figs. Sept. 25: Types and features of design; points out that heating capacity of furnace is based upon (1) temperature equalization in charge, (2) heat transfer to charge, (3) liberation of generation of heat. Oct. 2: Selection of cheapest fuel, everything considered; furnace design to utilize that fuel to best advantage; circulation of gases.

Developments. Industrial Furnaces (Industrieöfen), L. Weiss. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 39 and 41, Sept. 25 and Oct. 9, 1926, pp. 1281–1287 and 1359–1361, 33 figs. Historical development of reverberatory-furnace design in relation to metallurgical industry; development of electric arc in connection with aluminum production; fuels employed and their calorific values; different types of melting and annealing furnaces of latest designs; calculation of their probable fuel consumption and efficiency.

G

GASES

Density. A Review of the Literature Relating to the Normal Densities of Gases, M. S. Blanchard and S. F. Pickering. U. S. Bur. of Standards—Sci. Papers, no. 529, 1926, pp. 141–177. Attempt has been made to choose most reliable value for each gas.

GEARS

Bakelite. Bakelite Gears an Important Factor in Automotive Equipment, B. Boyce. Plastics, vol. 2, no. 9, Sept. 1926, p. 305, 1 fig. Gears made of laminated bakelite—sheets of cloth fiber impregnated with phenol resin in liquefied form, and firmly solidified by process of heating under pressure; at present applications are confined principally to intermediate gears and to pinions.

Inspection. Methods and Means Used for Small-Gear Inspection, P. W. Rhame. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 409–412, 9 figs. Great attention is necessarily paid to quality of speedometer gears as regards quietness of operation, free action and long life; great consideration is given to preventive measures, such as thorough inspection of cutters and concentrated supervision of work in progress on machines.

Teeth, Strength of. Strength of Gear Teeth, E. Kieft. Iron & Steel Engr., vol. 3, no. 9, Sept. 1926, pp. 405–415, 5 figs. Stresses due to load and shock.

Worm. Worm Gearing, H. E. Merritt. Machy. (Lond.), vol. 28, nos. 725, 726, 727, and 728, Sept. 2, 9, 16, and 23, 1926, pp. 648–650, 684–685, 716–718, and 743–744, 11 figs. Sept. 2: Undercutting; assembly interference; choice of thread section. Sept. 9 and 16: DBS standard module system of worm-gear design; basis of system; standard worm forms; calculation and choice of module; specification of work; addendum, dedendum, and clearance; calculation of lead angle and normal module pitch; example of calculation of work and wheel dimensions. Sept. 23: Tooth reaction: journal and thrust loads.

Worm Gearing—Comment, F. W. Shaw. Machy. (Lond.), vol 28, no. 728, Sept. 23, 1926, p. 747, 1 fig. Critical discussion of series of articles by H. E. Merritt in same journal, with special reference to assembly interference; author questions whether this really exists, and claims that it is not possible to generate wheels which will not assemble radially.

GRINDING

File Blanks. Grindstone Gear for File Manufacture (Schleifsteingetriebe der Feilenfabrikation), P. Haupt. Maschinenbau, vol. 5, no. 18, Sept. 16, 1926, pp. 838–843, 18 figs. Characteristics and treatment of large grindstones; bearings, calculation of gearing; fittings, driving, guards, etc.

GRINDING MACHINES

Cutter. Automatic Universal Cutter Grinder. Machy. (Lond.), vol. 28, no. 726, Sept. 9, 1926, pp. 686–687, 3 figs. Machine is intended for dry grinding, 3-in. suction pipe being provided for removing particles of abrasive.

Locomotive-Axle. Locomotive-Axle Grinding Machine. Engineering, vol. 122, no. 3167, Sept. 24, 1926, pp. 400–401, 4 figs. Equipment employed for locomotive-axle grinding.

Tap. Semi-Automatic Tap Grinder. Mech. World, vol. 80, no. 2073, Sept. 24, 1926, pp. 239–240, 4 figs. Machine, manufactured by Schuchardt & Schütte, Berlin, Germany, is for relieving taps by grinding and is claimed to produce smoothly finished tap having correct relief and which will cut evenly on all edges.

Vertical-Spindle. Vertical Spindle Surface Grinding Machine. Engineer, vol. 142, no. 3689, Sept. 24, 1926, p. 342, 2 figs. Built by Beyer, Peacock & Co., Manchester, Eng., for toolroom work such as finishing of templets, gages, etc., and grinding of small details.

Worm. New Automatic Worm Grinder. Iron Age, vol. 118, no. 14, Sept. 30, 1926, p. 928, 2 figs. New machine for thread grinding on production basis made by Pratt & Whitney Co., Hartford, Conn.

H

HAMMERS

Steam. Chambersburg Double-Frame Steam Hammer, Type B. Am. Mach., vol. 65, no. 15, Oct. 7, 1926, p. 613, 1 fig. Anvil is solid and cores have been avoided except at side for handling purposes.

HARDNESS

Testers. Comparison of Various Methods of Measuring Hardness of Tempered Metals (Les résultats comparatifs des diverses Méthodes de mesure de la dureté des métaux trempés), N. Sawine. Génie Civil, vol. 89, no. 8, Aug. 21, 1926, pp. 159–161, 7 figs. Discusses methods of Vickers, Hultgren, Rockwell, Brinell, Amsler, Baumann, and gives comparative figures.

HEAT TRANSMISSION

Skin Friction and. Further Experiments on the Relation Between Skin Friction and Heat Transmission, D. Marshall. Aeronautical Research Committee—Reports and Memoranda, no. 1004, Nov. 1925, 19 pp., 11 figs. Tests made on short heated section of pipe 5 in. in diameter through which current of air was forced, heat transmitted being estimated from rise of temperature of air; tests made on thin short cylinders or rings of nickel supported in 3-ft. wind channel and heated electrically, heat transmitted being measured from energy supplied to rings.

HEATING

Large Buildings. General Principles of the Heating of Large Buildings, W. W. Nobbs. Domestic Eng. (Lond.), vol. 46, no. 9, Sept. 1926, pp. 183–185. Problems which beset both architect and engineer; heating systems applicable to large buildings; discusses hot air, steam, and hot water, giving special applications and advantages of each.

HEATING, ELECTRIC

Industrial. Industrial Electric Heating, J. H. Crossley. Elecn., vol. 97, no. 2522, Oct. 1, 1926, pp. 386–387 and 392, 5 figs. Discusses baking and other important applications; saving space.

HUMIDITY

Calculation. The Calculation of Atmospheric Humidity, A. L. Egan. S. African Min. & Eng. Jl., vol. 37, no. 1818, July 31, 1926, pp. 621–622, 1 fig. Author develops new method for determining humidity.

HYDRAULIC TURBINES

German. Hydraulic Turbines of German Design (Der deutsche Wasserturbinenbau), A. Ungerer. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 21, 23 pp., 14 figs. Examples are cited to indicate difference in annual output in variable hydroelectric plant between Kaplan turbines and propellers with fixed vanes; further comparison shows that as far as average output throughout year is concerned, properly designed Francis turbines give similar results to those attained with Kaplan turbines; largest Pelton wheels now working in Germany are at Walchensee and Schwarzenbach, these being 20,000 and 27,500 hp. respectively.

Net Head. Notes on the Definition of Net Head as Used for the Experimental Determination of Turbine Efficiency, R. Neeser. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 62a, 9 pp. As defined in Switzerland and in Europe generally net head is actual operating head on turbine wheel; gives American definition of net head set up by standard testing code for hydraulic turbines, adopted by Machinery Builders' Society, Oct. 11, 1917; author expresses wish that there should be universal agreement, not only on subject of net-head definition and efficiency, but on the whole question with regard to experimental determination of efficiency of hydraulic machines. See also abstract in Engineering, vol. 122, no. 3169, Oct. 8, 1926, pp. 441–443.

Propeller Type. Swiss Test New Propeller Type Runner, F. Johnstone-Taylor. Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, p. 1066, 3 figs. Draft-tube design proves important in high-speed installation at Matte power station, Berne, Switzerland.

Regulating Gates. Hydraulic Turbine Regulating Gates, L. H. Burpee. Can. Engr., vol. 51, no. 10, Sept. 7, 1926, pp. 267–271, 5 figs. Operating difficulties in connection with them; effects of trash in turbine casing; gate mechanisms, renewable parts; correction of "sprung" gates; record of gate troubles at several Canadian plants.

Runners, Air Admission to. Admitting Air to Turbine Runners Improves Efficiency, S. L. Kerr. Power, vol. 64, no. 16, Oct. 19, 1926, pp. 580–582, 4 figs. Methods of admitting air to turbine runners to improve efficiency and how to make tests to determine adjustment of air valves to obtain most efficient operating performance.

Specifications. Specifications for Hydraulic Turbines, J. S. Carpenter. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1118–1120. Points out that uniform practice with regard to specifications is needed to eliminate misunderstandings.

Sweden. Turbine Designs: Latest Progress in Sweden, H. Munding. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 31, 15 pp., 11 figs. Turbines in Trollhättan are provided partly with internal and partly with external regulation; turbine shaft possesses flange in center of draft tube without bearings in its vicinity; vertical one-wheel turbines in concrete spirals are being more and more utilized in Sweden, where modern rapid wheels according to design of Lawaczeck and Dahl are increasingly used.

Swiss. Water-Power Utilization and Inland Navigation (Wasserkraftnutzung und Binnenschiffahrt), A. L. Caflisch. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 53, 26 pp., 16 figs. Hydraulic turbines by Swiss concerns, turbines of propeller, screw and Kaplan types which have been installed in low-head stations, have realized efficiencies up to 91 per cent with specific speeds up to 900; for very large output, high-head Francis turbine with vertical shaft has been developed to high state of perfection; impulse turbines of horizontal-shaft type have been built with great economic efficiency; new principles of quantity production have been applied to manufacture of governors; pipe lines are constructed with view to best utilization of material and minimum loss of head.

HYDRAULICS

Parameters, Use of. On the Use of vd/ν As a Parameter in the Practice of Hydraulics, E. Parry. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 3, 11 pp., 2 figs. Author advocates abandonment of all empirical formulas for coefficient of frictional resistance in hydraulics and substitution from series of curves determined by experiment, each curve representing particular degree of roughness in relation to diameter; points out that such series of curves are universal in character and apply equally to all fluids, gaseous or liquid, and at all temperatures. See abstract in Engineering, vol. 122, no. 3170, Oct. 15, 1926, pp. 474–475, 2 figs.

HYDROELECTRIC DEVELOPMENTS

France. Hydro-Electric Development in France. D. Fitz. Roy. Engrs. Jl., vol. 40, no. 3, Sept. 1926, pp. 458–468, 13 figs. Geographical distribution of water power in France; nature of works; high-head plants; economics of water power.

Ontario. Eighteenth Ontario Hydro Report. Contract Rec., vol. 40, no. 38, Sept. 22, 1926, pp. 901–903, 4 figs. Peak load to Oct. 1925, reached total of almost 900,000 hp.; small surplus capacity; statement on rates.

Power Developments on Gatineau River. Can. Engr., vol. 51, no. 13, Sept. 28, 1926, pp. 321–324, 6 figs. Two power developments, storage reservoir dam, and large newsprint mill under construction in Gatineau River district, Chelsea and Farmer's Rapids power developments; new mill of International Paper Co.; transmission lines.

Washington. Skagit River Hydro-Electric Development for Seattle, J. D. Ross. West. Constr. News, vol. 1, no. 18, Sept. 25, 1926, pp. 26–31, 10 figs. Commencement of $63,000,000 program; 4.25-mi. extension of railway to dam site in Diablo Canyon; construction of dam 365 ft. high to follow soon after.

HYDROELECTRIC PLANTS

Automatic. Automatic Hydro-Electric Power Stations in Sweden, E. Zachrisson. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 32, 7 pp., 4 figs. Instructions for automatic working of small hydroelectric plants, special stress being laid on making plants simple, reliable, and cheap; describes two plants, one consisting of two semi-automatic stations in Stallberg, and other consisting of two stations at Gefle, operated and controlled from distance; also describes automatic and uncontrolled switching station connecting two electric systems.

Automatic and Supervisory Control. Automatic and Supervisory Control of Hydroelectric Generating Stations, F. V. Smith. Am. Inst. Elec. Engrs—Jl., vol. 45, no. 10, Oct. 1926, pp. 967–973, 8 figs., and (discussion), pp. 1029–1035, 2 figs. Application of automatic equipment and supervisory control to number of interesting hydroelectric installations; operation of standard equipment, function performed by it and protective measures provided; high-speed synchronous relay type of supervisory control and remote metering.

Combined Steam and. Economic Problems of Water Power and Interconnections Between Hydro-electric and Steam Plants (Considérations économiques sur l'energie hydro-électrique et les liaisons entre centrales hydro-électriques at centrales thermiques), M. Lassalle. World Power Conference, Sect. Basel Meeting, 1926—Advance Paper, no. 7, 20 pp., 6 figs. Points out that nearly all power stations in Belgium use coal; sale price of electricity by hydroelectric plant would therefore be generally governed by tariffs of coal stations; hydroelectric station, if working alone, will thus be able to sell energy corresponding to minimum supply of water at same price as energy derived from combustion of coal; this is called first-class energy; excess of energy above this amount will have value in so far as it saves energy which steam station, connected up with hydraulic one, would have to generate; part of this excess, called second-class energy, will allow some generators of same station to be shut down, thus saving coal, oil, wear, and tear, etc.; another part called third-class energy, will save only coal, no generator being stopped.

Interconnection of Hydroelectric and Steam Plants (Hydroelektrische Verbundwirtschaft unter Mitwirkung kalorischer Anlagen), R. Hofbauer. World Power Conference, Sect. Basel Meeting, 1926—Advance Paper, no. 16, 15 pp., 7 figs. Discusses question of cooperation between steam and hydroelectric plants in Austria.

Construction. Distinctive Features of Hydro-Electric Construction, L. F. Harza. Elec. World, vol. 88, no. 13, Sept. 25, 1926, pp. 657–661, 5 figs. Discusses phases of hydroelectric construction; factors which determine schedule; making draft-tube forms ready for excavation; grading methods; progress records.

Economical Hydro-Electric Plant Construction, J. F. Vaughan. Elec. World, vol. 88, no. 13, Sept. 25, 1926, pp. 627–628. Importance of seeking to control fixed charges; rewards of detailed planning; individual responsibility more important than contract forms.

Electrical Equipment. Electrical Equipment of Swiss Design for Hydroelectric Plants (Die elektrischen Einrichtungen hydro-elektrischer Werke schweizerischer Herkunft), W. Wyssling. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 61a, 27 pp., 11 figs. Original data supplied by Swiss concerns are used to illustrate progress and general tendency in design, as exhibited in Switzerland, of following classes of equipment: electric generators, arrangement of exciters and voltage regulation, large power transformers, switches, etc.

France. The Eguzon Hydro-Electric Power Station, L. B. Desbleds. Elecn., vol. 97, no. 2521, Sept. 24, 1926, pp. 351–353, 6 figs. Long-distance supply of Paris; meeting traction load on Orléans Railway; interconnection with Gennevilliers; constructional details.

International Exposition, Switzerland. International Exposition for Inland Navigation and Water Power Utilization (Internationale Ausstellung für Binnenschiffahrt und Wasserkraftnutzung). Schweiz. Elektrotechnischer Verein—Bul., vol. 17, no. 8, Aug. 1926, pp. 337–384, 34 figs. Details of Swiss exhibits covering hydroelectric plants, transmission system and equipment, output, switch plant, hydrography, hydraulics, turbines, testing materials, etc.

Italy. The Arquata Scrivia Plant of the Edison Co. (L'officina di Arquata Scrivia della Societa Edison), G. Guastalla. Energia Elettrica, vol. 3, no. 6, June 1926, pp. 459–483, 36 figs. Describes plant and equipment, consisting of repair shop, transformer station (130,000 volt.), generating plant of 3 groups of asynchronous alternators of 6500 kw. each, and synchronous condensers of 6000 kva., switch plant, busbars, etc.

Low-Pressure. Low-Pressure Hydroelectric Plants (Niederdruckwasserkraftwerke), H. E. Gruner. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 26, 14 pp., 1 fig. Capacity of low-head plants of Switzerland is considerably larger than capacity corresponding to minimum flow; investigation of performance of such plants must include determination of daily output over large number of years; it is not advisable to locate weirs behind convex part of bend in river; weirs in Switzerland are invariably built with sluice gates; cross-section of power house is determined by type of turbine installed; most recent stations are equipped with turbines of vertical-shaft type.

Small. The Smallest Hydroelectric Generators (Kleinste Wasserkraft-Stromerzeuger), C. Reindl. Schweizerische Bauzeitung, vol. 88, no. 8, Aug. 21, 1926, pp. 126–127, 3 figs. Describes 1.5-kw. plant built by Esslingen Maschinenfabrik, direct coupled turbine and dynamo, for heads of 3 to 20 m.; whole plants occupies space of 2 sq. m. on foundation of 50 by 50 cm.

I

INDUSTRIAL MANAGEMENT

Automobile Manufacturing Plants. A Simple Works System. Automobile Engr., vol. 16, no. 219, Sept. 1926, pp. 343–347, 12 figs. Organization of automobile factory for moderate and varied output.

Budgetary Control. Budgetary Procedure for the Rubber Industry. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 283–288. Miscellaneous adjustments; forecast of collections from accounts receivable; estimated profit and loss statement; comparison form budget versus actual amounts monthly and to date.

Business Forecasting. We Owe 1926 Profits to Our Business Forecast, H. Coonley. Factory, vol. 37, no. 4, Oct. 1926, pp. 591–595, 660, 662, 748, and 750. Practice of planning department of Walworth Co., Boston; from study of coming year's sales it is possible to arrive rather definitely at what costs and prices will be.

Cost Control. Reorganizing Metal-Working Shops for Small-Scale Production (Die Umstellung metallbearbeitender Betriebe mit Kleinserienfertigung), H. Ludwig. Maschinbau, vol. 5, no. 16, Aug. 19, pp. 729–736, 8 figs. Discusses effect of direct and indirect operating costs; shop organization for small-scale production; store keeping; etc.

Costs and Selling Prices. Normal Costs and Selling Prices, L. P. Alford. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 269–272, 1 fig. Deals with following questions: What constitute costs, how much profit should be made, and how should selling prices be set?

Economical Manufacturing Quantities, Determining. How to Determine Economical Manufacturing Quantities, B. Cooper. Indus. Mgmt. (N. Y.), vol. 72, no. 4, Oct. 1926, pp. 228–233, 7 figs. Method for determining most economical manufacturing quantities, incorporating both accuracy and relative simplicity; formulas and charts are developed.

Production Control. A Flexible Production Control System, E. J. Kunze. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 289–292, 5 figs. System applied to both manufacturing and special orders.

Seasonal Production. Solving a Seasonal Production Problem by Automatic Machinery, C. L. Carpenter and R. E. Kinkead. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 281–282, 3 figs. Solution of problem of getting large quantity, high-quality production on short notice at plant manufacturing sewage-disposal tanks came with development and installation of Lincoln automatic carbon arc-welding equipment; with this equipment a few machine operators can turn out at any time more than double output of former manual operators.

Taylor System. Taylor System of Scientific Management (Il sistema Taylor d'organizzazione scientifica del lavoro), L. A. Boncinelli. Industria, vol. 40, no. 11, July 1926, pp. 283–285. Discusses advantages and disadvantages, and analyses results of application of Taylor system in Italy; conclusions are in its favor generally.

Time Study. See TIME STUDY.

World Progress. The World Movement of Scientific Organization. Int. Permanent Delegation of Sci. Mgmt. Congress, vol. 1, no. 1–2, June 1926, pp. 16–27. Deals with technical science and management; importance, endeavors and progress of scientific organization. See same article in French, pp. 4–15.

INDUSTRIAL ORGANIZATION

Pacific Gas and Electric Co. Administrative Methods of the Second Largest Gas and Electric Company in the Country, Chas. W. Geiger. Indus. Mgmt. (N. Y.), vol. 72, no. 3, Sept. 1926, pp. 196–199. Operating and service departments represent two dimensions of organization; one specializes on particular kind of operation and other on particular kind of service; third dimension is represented by geographic division into which territory served is divided; industrial-relation activities; department of engineering and of functional organization; electric distribution and steam engineering; specifications and estimates.

INDUSTRIAL RELATIONS

N. E. L. A. Committee Report. Report of Industrial Relations Committee 1925–1926. Nat. Elec. Light Assn.—Report, no. 256–32, May 17–21, 1926, 29 pp., 7 figs. Studies of phases of employment, compensation, and pensions.

Plant Program. Plan Wins Employees Good Will, B. Finney. Iron Age, vol. 118, no. 13, Sept. 23, 1926, pp. 835, 1 fig. Industrial-relations program in moderate-sized plant of Diamond Chain & Mfg. Co., Indianapolis; individual instruction given apprentices; group insurance and mutual-relief association are features.

INDUSTRIAL TRUCKS

Electric. Saving in Foundry Handling with the Electric Industrial Truck, H. J. Payne. Am. Foundrymen's Assn.—Preprint no. 11, for mtg. Sept. 27–Oct. 1, 1926, 16 pp., 10 figs. Sand, pig, scrap, cores, flasks, molten metal, semi-finished castings, annealing pots, and finished castings can be handled effectively with industrial truck in most cases; describes practice of Erie Malleable Iron Co.; performance of pot-charging truck and higher-capacity lift-truck units; use of auxiliaries such as special skids, scales, forks for converting standard elevating platform equipment to pot-handling trucks.

INSULATION, HEAT

Furnaces. Selection of Proper Furnace Insulation, M. H. Mawhinney. Forging—Stamping—Heat Treating, vol. 12, no. 9, Sept. 1926, pp. 328–333, 12 figs. Also Blast Furnace & Steel Plant, vol. 14, no. 10, Oct. 1926, pp. 426–431, 12 figs. Suggestions for selection of proper furnace insulation for various conditions which are commonly found in practice.

INTERNAL-COMBUSTION ENGINES

Cooling. Notes on Internal-Combustion Engines (Betrachtungen uber Verbrenungsmotoren), H. Koschmieder. Brennstoff u. Wärmewirtschaft, vol. 8, nos. 15 and 16, Aug. 1st and 2nd nos., 1926, pp. 237–239 and 265–267, 1 fig. Discusses internal cooling by injecting water into combustion gases or by transmitting heat produced to air, and makes calculations; shows that it is possible to design internal-combustion engines without external water cooling with very good efficiency.

Detonation in. The Effect of Metallic Sols in Delaying Detonation in Internal Combustion Engines, C. J. Sims and E. W. J. Mardles. Aeronautical Research Committee—Reports and Memoranda, no. 1021, May 1926, 11 pp. It was found that colloidal solutions of iron, lead, and nickel in gasoline are as effective in delaying detonation as organic compounds of these metals; metallic iron seems to be more effective than its carbonyl compound.

German Types. New Internal-Combustion Engines at the Leipzig Spring Fair (Neue Brennkraftmaschinen auf der Technischen Frühjahrsmesse zu Leipzig), F. Wilcke. Brennstoff u. Wärmewirtschaft, vol. 8, no. 14, July 2nd no., 1926, pp. 223–228, 4 figs. New types of compressorless engines; ante-chamber process (hot or cold); fuel injection under pressure without ante-chamber; compressorless 4-stroke oil engines with auto-ignition, etc.

Horizontal Multi-Cylinder. The Case for the Horizontal Multi-Cylinder Internal Combustion Engine, R. M. H. Lewis. Roy. Engrs. Jl., vol. 40, no. 3, Sept. 1926, pp. 403–410, 12 figs. Criticizes various claims for superiority put forward on behalf of vertical multi-cylinder engine; advantages of horizontal type.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

IRON CASTINGS

Gating. On Gating Iron Castings, H. W. Dietert. Am. Foundrymen's Assn.—Preprint no. 26, for mtg. Sept. 27–Oct. 1, 1926, 11 pp., 4 figs.; also abstract in Foundry Trade Jl., vol. 34, no. 529, Oct. 7, 1926, pp. 313–314 and 316, 4 figs. To determine factors of gating in common use in plant with which author is connected, study was made of rates of pouring of castings according to weights; pouring times of numerous molds were plotted against weights of castings in molds; data secured show that there is definite relation between pouring time and weight; as result of investigation, charts were developed which enables foundry organization to specify sizes of gates for various castings and rates of pouring.

L

LABORATORIES

Boiler. The Laboratory of a Boiler Factory (Versuche- und Forschungsanstalt einer Dampfkesselfabrik). Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 35, Aug. 28, 1926, pp. 42–43, 4 figs. Equipment and arrangement of testing and research station of firm of L. & C. Steinmüller, Gummersbach, including laboratory for boiler feedwater and fuel investigation, and foundry, metallographic and material-testing laboratories.

Heat-Treatment. Heat Treatment Industrial Laboratories. Metal Industry (Lond.), vol. 29, no. 13, Sept. 24, 1926, pp. 290–291, 2 figs. Methods and equipment of laboratory of city of Birmingham Gas Department, England; details of recuperator furnaces and temperature recorders; research work; demonstrations on commercial scale of hardening, tempering, case-hardening, or normalizing.

Hydraulic. Hydraulic Laboratories at Verkstaden, Kristinehamn, Sweden, H. Lind. Engineering, vol. 122, nos. 3167, 3168, and 3169, Sept. 24, Oct. 1 and 8, 1926, pp. 374–376, 405–407, and 439–441, 20 figs. Testing station constructed in 1906 at water fall situated inside works' boundaries, and rebuilt and enlarged in 1915 so as to fit it for rapid and reliable tests of turbines of all types and specific speeds; dam situated above test-

ing station is provided with head gates and long spillway, with arrangements for easy regulation of upper water level; in most tests head of 4 m. is adopted.

The Laboratory for Hydraulic Machinery at the Hannover Polytechnic (Das Laboratorium für Wasserkraftmaschinen an der Technischen Hochschule Hannover), F. Oesterlen. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 37, Sept. 11, 1926, pp. 1225–1229, 8 figs. Details of laboratory, completed in 1923, for investigation of different types of hydraulic turbines with vertical and horizontal shaft; water measurement by means of screen or shutter, overfall and Woltmann blade wheel; gaging channel with measuring scale; etc.

Metallographic. Wheel Makers Expand Laboratory, R. A. Fiske. Iron Age, vol. 118, no. 13, Sept. 23, 1926, pp. 838–840, 4 figs. Test specimens studied in new metallographic department of Assn. of Manufacturers of Chilled Car Wheels; laboratory is located at plant of Griffin Wheel Co., Chicago, where facilities of chemical laboratory are available to supplement microphotographing and physical testing equipment owned by Association.

Methods and Equipment. Laboratory Technique, Methods and Equipment, F. Jehle. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 373–384, 14 figs. Methods to be followed in making investigation are elucidated by examples of study of adapting existing carburetor to existing engine and of study of charge distribution by manifold to cylinders of four-cylinder engine.

LACQUERS

Inflammable, Storage and Handling of. Storage and Handling of Inflammable Lacquer Materials. Paint Mfrs.' Assn. of U. S., Sci. Section—Circular, no. 285, Sept. 1926, pp. 133–139. Approved methods for safe handling, storage, and use of inflammable materials in lacquer industry.

LATHES

Developments and Uses. Development and Use of the Lathe, L. A. Catlin. Can. Machy., vol. 36, no. 12, Sept. 16, 1926, pp. 15–17, 7 figs. It is shown that development of lathe through ages was slow. (Abstract.) Paper read before Glasgow & West of Scotland Assn. of Foremen Engrs.

Flywheel Machining in. Machining of Flywheels. Brit. Machine Tool Eng., vol. 4, no. 41, Sept.-Oct. 1926, pp. 478–479, 2 figs. Butler flywheel turning, boring, and bossing lathe on which gas-engine flywheel 5 ft. in diameter may be completely finished in 3 hours, 50 minutes; machine is provided with five cutting tools, all of which may be in operation simultaneously.

Vertical Boring and Turning. Cooling-Water Device for Vertical Boring and Turning (Kuhlwassereinrichtung an Karusselldrehbänken), P. Uhlich. Maschinebau, vol. 5, no. 16, Aug. 19, 1926, pp. 741–743, 7 figs. Tests of efficiency of these lathes with and without cooling; cooling arrangement for various types of lathes.

LIFTING MAGNETS

Operation. The Operation of Lifting Magnets (Der Betrieb von Lasthebemagneten), F. Windrath. Fördertechnik u. Frachtverkehr, vol. 19, no. 19, Sept. 17, 1926, pp. 285–286, 2 figs. Main factors to be considered in feeding from a consant d.c. network; describes special rotary converter which is started in single- or multi-phase a.c. systems simultaneously with magnet.

LOCOMOTIVE BOILERS

Water-Tube. Structural Changes in the McClellon Watertube Locomotive Boiler. Boiler Maker, vol. 26, no. 9, Sept. 1926, pp. 249–255, 11 figs. Side watertube arrangement altered in recent order for 10 locomotives for New York, New Haven & Hartford R. R.

LOCOMOTIVES

Design. Some Important Details, C. T. Ripley. Ry. Age, vol. 81, no. 12, Sept. 18, 1926, pp. 499–500. Discusses question of design of detailed parts of locomotive, particularly those features which need improvement; expansion stresses in firebox; frames and moving parts; need of cross-counterbalancing.

Diesel-Engined. Diesel Locomotive Operation in Russia, G. V. Lomonossoff. Ry. Rev., vol. 79, no. 13, Sept. 25, 1926, pp. 457–459, 5 figs. Gear-magnetic transmission compared with electric drive and gear-shift system.

Diesel Locomotives for Main Line Traffic. Ry. Engr., vol. 47, no. 561, Oct. 1926, pp. 357–363 and 368, 11 figs. Two separate designs for Russia, one with electric and other with geared transmission; first was supplied by Brown-Boveri & Co. and is 2–10–2 type; and other is 4–10–2 type, supplied by Hohenzollern Works, Germany; locomotive-testing plant.

Diesel-Hydraulic. Diesel-Hydraulic Locomotive According to Rosen System (Diesel-Hydrauliskt lokomotiv enligt system Rosen), C. E. Uddenberg. Teknisk Tidskrift (Mekanik), vol. 56, no. 20, May 15, 1926, pp. 57–60, 6 figs. 1-B-1 locomotive with Adams-type carrying axles, 12-cylinder Atlas Diesel of 300 hp. 550 r.p.m.; maximum speed 70 km. per hr., maximum load 4000 kg.; hydraulic transmission of power to driving wheels by chains.

Electric. See ELECTRIC LOCOMOTIVES.

Hanomag. Economic Locomotives for Narrow-Gage Lines, Factories and Mills (Wirtschaftliche Lokomotiven für Neben-, Klein-, Werks- und Hüttenbahnen), K. Ewald. Hanomag Nachrichten, vol. 13, no. 152–153, June–July 1926, pp. 73–81, 14 figs. Describes various types, their equipment, upkeep, suitability for given work, etc.

Horsepower Output. High Horsepower Output Cuts Operating Costs, W. E. Woodward. Ry. Age, vol. 81, no. 12, Sept. 18, 1926, pp. 495–497. Discusses fundamental problem of how increasing drawbar horsepower, which future traffic will demand, can be obtained; recent steps in locomotive development; higher boiler capacity. Paper read before Traveling Engrs.' Assn. See also Ry. Rev., vol. 79, no. 13, Sept. 25, 1926, pp. 475–477, 3 figs.

Lubrication. Lubrication of Steam Locomotives, G. W. Armstrong. Ry. Mech. Engr., vol. 100, no. 10, Oct. 1926, pp. 587–589, 2 figs. Relative merits of oil and grease for lubricating.

Modern. The Locomotive of Today, S. O. Dunn. Ry. Age, vol. 81, no. 12, Sept. 18, 1926, pp. 492–495. Points out that about 68 per cent of active engines are over 10 years old; gross ton-miles per train-hour best measure of performance. Address before Traveling Engrs.' Assn.

Oil-Electric. Oil Electric Locomotive on Eight Railroads. Oil Engine Power, vol. 4, no. 10, Oct. 1926, pp. 623–624, 2 figs. General review of results obtained to date shows possibilities for vast expansion.

Steam, Electric and Oil-Electric Locomotives (Dampflokomotive, elektrische- und thermolokomotive. Ein weltwirtschaftlich-technisches Problem), E. Kurzel-Runtscheiner. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 56, 29 pp. Up to present time steam locomotive predominating in bulk traffic still retains basic features of original Stephenson constructions; development of gasoline-electric locomotives in Russia, aided by German industry, and in Austria; methods used for overcoming difficulties; most remarkable are transmission of energy by gaseous mediums, by hydraulic gearing, by electric power transmission, and by spur gearing. Bibliography.

Operation. Improved Operating Methods Accompany Improved Locomotives, A. R. Ayers. Ry. Age, vol. 81, no. 12, Sept. 18, 1926, pp. 497–499. Discusses conditions which locomotives must meet from operating standpoint. Paper read before Traveling Engrs.' Assn. See also Ry. Rev., vol. 79, no. 13, Sept. 25, 1926, pp. 473–475.

Pacific. Pacific Type Locomotives for the A. & W. P. and W. of A. Ry. Age, vol. 81, no. 14, Oct. 2, 1926, pp. 641–642. Designed to haul heavy passenger trains over rolling division; develop tractive force of 47,500 lb.; built by Lima Locomotive Works.

Steam-Turbine. Visit to Santa Fé and Inspection and Trial of Ljungström Turbo-Condensing Locomotive. Ry. Gaz., vol. 45, no. 11, Sept. 10, 1926, pp. 310–312, 3 figs. Account of locomotive in service; test results; spark-prevention devices on locomotives.

Switching. New Shunting Locomotive, Great Western Railway. Ry. Gaz., vol. 45, no. 13, Sept. 24, 1926, pp. 365, 2 figs. Built by Aconside Engine Co., Bristol, for use in Swansea docks.

Three-Cylinder. Three-Cylinder Mountain Type Locomotives for the Denver & Rio Grande Western Railroad Co. Ry. & Locomotive Eng., vol. 39, no. 9, Sept. 1926, pp. 245–246, 1 fig. Built by Baldwin Locomotive Works for heavy passenger service.

LUBRICATING OILS

Deleterious Properties. Some Deleterious Properties of Lubricating Oils, J. F. Hackford. Diesel Engine Users Assn.—Report, no. S 72, for mtg. June 25, 1926, 22 pp., 2 figs. Author describes tests that may help to predict future behavior of oil; includes discussion.

Kerosene Addition. The Effect of the Addition of Kerosene on the Oiliness of Lubricating-Oils, S. A. McKee. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 356–360, 6 figs. Results of tests of performance of oils diluted with kerosene in journal-bearing friction machine with regard to so-called oiliness property of lubricant, oiliness being defined as property that causes difference in friction when two lubricants of same viscosity at temperature of oil film are used under identical conditions; method of procedure and precautions taken to keep speed, load, bearing temperature, and oil pressure constant throughout duration of run; results show that, under conditions of these tests, addition of kerosene decreases oiliness effect of lubricant.

Properties and Application. The General Properties of Lubricating Oils and Their Practical Application, A. E. Dunstan and R. W. L. Clarke. Chem. & Industry, vol. 45, no. 39, Sept. 24, 1926, pp. 690–694. Manufacture of lubricating oils from petroleum; nomenclature of lubricating oils; general properties.

M

MACHINING METHODS

Cost Reduction. Reducing Machining Costs. Machy. (Lond.), vol. 28, no. 727, Sept. 16, 1926, pp. 701–708, 16 figs. Use of specially prepared forms of metals; bright drawn steels, turned and ground stock, hollow bars and seamless tubing, die castings, hot pressing and stampings, close-to-limit castings and extruded sections.

Ice Machines. Production Methods in an Ice-Machine Plant, F. W. Curtis. Am. Mach., vol. 65, no. 16, Oct. 14, 1926, pp. 623–625, 9 figs. Methods and equipment of Baker Ice Machine Co., Omaha, Neb.

MALLEABLE CASTINGS

Black-Heart. Black-Heart Malleable (Remarques sur la malléable à coeur noir), C. Kluytmans. Fonderie Moderne, vol. 20, Sept. 1926, pp. 209–214, 12 figs. Discusses defects of black-heart malleable produced in reverberatory furnace, originating in crude metal of casting, and in annealing, and gives examples.

Properties. A Study of Malleable Cast Iron, O. Quadrat and J. Koritta. Am. Foundrymen's Assn.—Preprint no. 21, for mtg. Sept. 27–Oct. 1, 1926, 7 pp. Investigation to examine influence of temper carbon on physical properties of gray heart of malleable castings; effect of low and high temperatures and to determine tensile strength of ferritic material containing grains of temper carbon. Also abstract in Foundry Trade Jl., vol. 34, no. 529, Oct. 7, 1926, p. 306.

Requirements. What May Be Required of Malleable Cast Iron, H. A. Schwartz. Am. Foundrymen's Assn.—Advance Paper, no. 44, for mtg. Sept. 27–Oct. 1, 1926, 16 pp. What consumer desires; importance of physical requirements; quantitative description of physical properties; possible tests; yield point; machinability requirements; welded castings; heat treatment; question of chemical composition.

Strength. Resistance of Malleable Iron to Repeated Impact Stresses and Comparison of Strength of Machined and Unmachined Malleable Castings, E. Touceda. Am. Foundrymen's Assn.—Preprint, no. 39, for mtg. Sept. 27–Oct. 1, 1926, 9 pp., 2 figs. Results of tests.

METALS

Corrosion-Resisting. Metals to Resist Corrosion or High Temperatures, H. J. French. Am. Electrochem. Soc.—Advance Paper, no. 5, for mtg. Oct. 7–9, 1926, pp. 47–79, 6 figs. Principal characteristics and typical applications of metals used industrially to resist high temperatures or corrosion; those considered include commercially pure copper, aluminum, lead, tin, silver, nickel and iron, and their alloys.

Dilatometric Analysis. Principles and Chief Applications of Dilatometric Analysis of Materials, A. Portevin and P. Chevenard. Am. Foundrymen's Assn.—Advance Paper, no. 22, for mtg. Sept. 27–Oct. 1, 1926, 43 pp., 34 figs. Thermal and physical analysis; superiority of dilatometric analysis; calculation of coefficient of expansion; application of dilatometric analysis.

Molten, Heat of Mixing. Heat of Mixing of Molten Metals (Untersuchungen über Mischungswärmen geschmolzener Metalle), A. Magnus and M. Mannheimer. Zeit. für physikalische Chemie, vol. 121, no. 3–4, June 10, 1926, pp. 267–288, 3 figs. Direct and indirect methods have been employed in study of heat changes on mixing molten lead and tin, zinc and tin, lead and cadmium, tin and cadmium, and bismuth and tin in various proportions.

Pickling. Addition of Substances to Pickling Baths in the Metal Industries (Ueber Sparzusätze zu Beizbädern in der Metallindustrie), W. H. Creutzfeldt. Zeit. für anorganische u. allgemeine Chemie, vol. 154, June 6, 1926, pp. 213–219, 2 figs. Loss of weight of iron and steel plates, and increase in brittleness of wire, were determined after treatment under controlled conditions with sulphuric acid alone and with addition of various organic substances known to moderate its action; loss of weight was least when tar oil was added; many other organic substances retarded action of acid to smaller extent.

Plastic Deformation. The Question of Plastic Deformation, H. Preussler. Blast Furnace & Steel Plant, vol. 14, no. 10, Oct. 1926, pp. 442–447, 17 figs. Author gives insight into character of plastic deformation; various observations and theories discussed; application to rolling, forging, and pressing. Translated from Stahl u. Eisen.

MICROSCOPES

Toolmakers'. Bausch & Lomb Toolmakers' Microscope. Am. Mach., vol. 65, no. 16, Oct. 14, 1926, pp. 652 653, 2 figs. Principle of operations of instrument adapted to workshop and laboratory.

MILLING CUTTERS

Theory of Operation. Milling Cutter Operation (Die Fräsarbeit), C. Salomon. Werkstattstechnik, vol. 20, no. 15, Aug. 1, 1926, pp. 469–474, 8 figs. New theory based on detailed calculation, taking into account variability of specific cutting resistance; agreement of cutting tests, carried out at Henschel Locomotive Works, based on this theory.

MILLING MACHINES

Automobile Industry. Tooling 1927 Models of Auto Industry, H. Rowland. Can. Machy., vol. 36, no. 13, Sept. 23, 1926, pp. 14–16, 8 figs. Describes recent installations of productive milling equipment.

Universal. Large Universal Milling Machine. Machy. (Lond.), vol. 28, no. 728, Sept. 23, 1926, pp. 745–746, 5 figs. Machines built by P. Huré & Cie., Paris, using table with universal head; drive is by constant-speed single pulley; most interesting feature of machine is double swiveling head.

MOLDING METHODS

Differential-Pitch Propellers. Metal Industry (Lond.), vol. 29, no. 10, Sept. 3, 1926, pp. 223–224, 6 figs. Most usual method is to employ inner and outer templets; explains why this is unsatisfactory method; author suggests that it is not only possible, but really simpler to strike it with one templet; sweeping bed is done by means of two boards, one being fixed to spindle and other being pinned to it near center.

MOLDS

Permanent. Permanent and Long Life Molds, R. Moldenke. Am. Foundrymen's Assn.—Advance Paper, no. 32, for mtg. Sept. 27–Oct. 1, 1926, 8 pp. Summarizes position of permanent and long-life mold in foundry industries; economical aspects of developments and utility of permanent molds; possible mold materials and trends of experimental work.

Permanent and Long Life Molds. Am. Foundrymen's Assn.—Advance Paper, no. 10, for mtg. Sept. 27–Oct. 1, 1926, 28 pp., 7 figs. Symposium of following papers: Durable Molds, J. A. Murphy; A. Permanent Mold Process, H. A. Schwarts; Some Considerations of Metal for Heavy Iron Castings in Permanent Molds, H. P. Kimber and S. M. Udale.

Sand, Melting Steel for. Melting Steel for Sand Molds, T. E. Hull. Foundry, vol. 54, no. 19, Oct. 1, 1926, pp. 785–787. Points out that requirements for castings differ from ingots; metal must be superheated; shrinkage and contraction; liquidity and fluidity. (Abstract.) Paper presented before West Yorkshire Met. Soc. of England.

MOTOR BUSES

Yellow Coach Mfg. Co. Investigations of a 40-Hp. Motor-Bus Chassis of the Yellow Coach Mfg. Co., Chicago, Ill., U. S. A. (Untersuchungen am 40 PS; Omnibus-Chassis der Yellow Coach Mfg. Co., Chicago, Ill., U. S. A.), G. Becker. Motorwagen, vol. 29, no. 19, July 10, 1926, pp. 423–431, 17 figs. Results of investigation at Experimental Institute for Automobiles of the Charlottenburg Polytechnic, Berlin.

MOTOR-TRUCK TRANSPORTATION

Pennsylvania Railroad. Pennsylvania Trucks Speed Up Service. Ry. Age, Motor Transport Sect., vol. 81, no. 13, Sept. 25, 1926, pp. 595–595, 7 figs. Local freight trains replaced on 1000 miles of line; trucks serve 500 stations.

MOTOR TRUCKS

Albion. New Albion Three-Tonner. Motor Transport, vol. 43, no. 1123, Sept. 20, 1926, pp. 343–346, 12 figs. Live-axle solid-tired freight-carrying design available also with pneumatic tires and front-wheel brakes.

Electric. The Commercial Use of Electric Vehicles, H. A. Child. Instn. Engrs. Australia, vol. 7, no. 2, 1926, pp. 37–64, 8 figs. History of development of electric vehicle; mechanical construction of trucks, design of motor, controller and battery; characteristics; charging and maintenance.

Quarry Transportation. Motor Trucks for Quarry Transportation, N. C. Rockwood. Rock Products, vol. 29, no. 19, Sept. 18, 1926, pp. 34–39, 24 figs. Trucks with special all-steel, 12-ton capacity bodies replace railway tracks, locomotives and cars at two general crushed stone company quarries.

MOTORCYCLES

British Show. The Cycle and Motor-Cycle Show at Olympia. Engineering, vol. 122, no. 3169, Oct. 8, 1926, pp. 453–454. Trend of frame and engine design.

N

NOZZLES

Steam. Some Deductions from Steam-Nozzles Research, T. Petrie. Engineering, vol. 122, no. 3171, Oct. 22, 1926, pp 495–497, 12 figs. As result of work of Steam-Nozzles Research Committee of Instn. Mech. Engrs., it appears that nozzles which work at velocities below flexure point require particular attention to be paid to their rates of convergence and of angle deviation, but that nozzles working at velocities between flexure point and critical velocity of sound in steam are subject to wide variation in angle and in shape without loss in efficiency, providing exit conditions beyond throat are carefully designed; roughly, it may be taken that flexure point occurs at half velocity of sound in steam.

O

OIL ENGINES

Maintenance. Factors That Influence Oil-Engine Maintenance, L. H. Morrison. Power, vol. 64, no. 16, Oct. 19, 1926, pp. 590–592, 3 figs. Points out that prestudy of plant conditions permits accurate prediction of repair costs.

OIL FUEL

Atomization in Burners. Factors Affecting Atomization in Oil Burners, J. F. Barkley. Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, pp. 1048–1049, 1 fig. Data secured and conclusions drawn from experiences with combustion of oil in power-plant furnaces.

Burners. Progress in Industrial Heating, L. Macleod. West. Machy. World, vol. 17, no. 9, Sept. 1926, pp. 388–390, 5 figs. Details of Ray fuel-oil burning system, which is supplied with oil from independent pump set; applications of these burners to industry.

Developments. Burning of Liquid and Gaseous Fuels. Nat. Elec. Light Assn.—Report, no. 25–106, Jan. 1926, 15 pp., 11 figs. Effect of furnace-volume upon maintenance, given by New Orleans Public Service; results of burning residuum from cracking stills as reported by Wichita Falls Electric Co.; progress made in burning of oil in combination with gas and coal, and results of recent developments and operating experience.

Handling From Car to Burner. Handling Fuel Oil from Car to Burner, W. C. Kammerer. Forging—Stamping—Heat Treating, vol. 12, no. 9, Sept. 1926, pp. 333–334, 2 figs. Sets forth important factors that must be taken into consideration in handling of heavy fuel oil from tank car to burner.

Research. Fuel and Lubrication Research, W. A. Whatmough. Automobile Engr., vol. 16, no. 219, Sept. 1926, pp. 329–330, 2 figs. Résumé of recent investigation in carburation and oils.

P

PAINTS

Life of. Paint and Varnish as Enemies of Corrosion, E. B. Timmerman. Can. Chem. & Met., vol. 10, no. 9, Sept. 1926, pp. 205–207. General discussion of factors affecting life of paint and varnish.

White. Primers for White Paints Used on Refrigeration Cork Board Insulations, H. A. Gardner. Paint Mfrs.' Assn. of U. S., Sci. Section—Circular, no. 288, Sept. 1926, pp. 150–154, 1 fig. Note on iron sulphate as stain preventive in applying white paints to some woods.

PATTERNMAKING

Band Saw, Use in. Band Saw is Important Pattern Shop Tool, W. C. Ewalt. Foundry, vol. 54, no. 18, Sept. 15, 1926, pp. 746–749, 14 figs. Points out that special care is necessary in successful operation of this machine tool, and also that safety measures are essential.

PHOTOELASTICITY

Eye-Shaped Bar-End Investigation. Eye-Shaped End of Bar Investigated by Photo-Elastic Method, K. Takemura and Y. Hosokawa. Aeronautical Research Inst., Tokyo Imperial Univ.—Report, vol. 11, no. 4, July 1926, pp. 127–143, 21 figs. Point of maximum stress at inner edge of eye-shaped end changes its position according to manner of loading, and magnitude of maximum stress varies considerably with contour of eye-shaped end.

PIPE, CAST-IRON

Centrifugally Cast. Experience with the Use of De Lavaud Centrifugally Cast Iron Pipe, P. J. Hurtgen. Am. Water Works Assn.—Jl., vol. 16, no. 3, Sept. 1926, pp. 373–386. Author relates actual experiences of water-works officials on use of de Lavaud pipe.

Stresses in Sockets. Stresses in Cast Iron Pipe Sockets. Engineer, vol. 142, no. 3690, Oct. 1, 1926, pp. 366–368, 7 figs. Investigation made by R. G. Batson and W. F. Cope at National Physical Laboratory; depth-gage measurements; mirror measurements; results indicated that initial stress set up by calking at outside of socket did not remain constant but gradually fell off with time, becoming approximately constant after about seven days; stresses in light-type socket caused by calking were higher than those in Brit. Eng. Standard Assn. socket with all types of joint; stresses in socket caused by internal pressure of 325 lb. per sq. in. were constant for all tests and of value of 0.8 tons per sq. in.

PLANERS

Helical-Gear. "Sunderland" Double Helical Gear Planer. Brit. Machine Tool Eng., vol. 4, no. 41, Sept.–Oct. 1926, pp. 465–473, 15 figs. Application of the Sunderland generating system as embodied in the new Parkinson-Sunderland double helical-gear planers.

POWER GENERATION

Hydraulic and Steam. Economic Relation Between Electrical Energy Produced Hydraulically and Electrical Energy Produced By Steam. Steam Turbines. (Wirtschaftliche Beziehungen zwischen hydraulisch erzeugter und thermisch erzeugter elektrischer Energie—Dampfturbinen), A. Meyer and W. G. Noack. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 79, 53 pp., 15 figs. When all factors are taken into consideration, it can be said that even in countries where fuel is comparatively expensive as in Switzerland, steam power plants are really on competitive basis with hydroelectric plants; combined steam power and heating plants have received of late increasing amount of attention because they represent, from thermodynamical standpoint especially, rational mode of operating heat plant; they are also of interest for steam power plants operating in conjunction with hydroelectric plants.

Economic Relation Between Electrical Energy Produced Hydraulically and Electrical Energy Produced by Steam. With Reference to Reports of Buchi, Meyer and Nesser (Betrachtungen uber die wirtschaftlichen Beziehungen zwischen hydraulisch und thermisch erzeugter elektrischer Energie, unter verwertung der Berichte der Herren Buchi, Meyer und Neeser), Ehrensperger. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 80, 29 pp., 4 figs. Survey of development and present condition of hydraulic and steam generation of energy in Switzerland; different types of power stations and conditions to which they are especially adapted.

The Economic Relation Between Electrical Energy Produced Hydraulically and Electric Energy Produced by Steam. Conditions Under Which the Two Systems Can Work Together with Advantage in Some Sections of the United States of America, W. E. Mitchell and J. L. Gallalee. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 76, 47 pp., 17 figs. See also abstract in Power, vol. 64, no. 15, Oct. 12, 1926, pp. 570–571.

PRESSWORK

Safety in Shop. A New Plan for Making the Press Shop Safe, P. J. Edmonds. Machy. (N. Y.), vol. 33, no. 2, Oct. 1926, pp. 121–124, 11 figs. How serious accidents have been eliminated in large metal-stamping plant.

PRINTING MACHINERY

Type Casting, Electric Heat for. Application of Electric Heat to Type Casting Machines. Nat. Elec. Light Assn.—Report, no. 256–286, Aug. 1926, 3 pp., 3 figs. Advantages of electric heat; types and makes of machines; operating data from specific installations; related equipment.

PROFIT SHARING

Great Britain. Profit Sharing. Monthly Labor Rev., vol. 23, no. 3, Sept. 1926, pp. 62–64. Profit sharing and labor copartnership in Great Britain and Northern Ireland in 1925.

PULVERIZED COAL

Boiler Firing. A New System for Firing Boilers with Powdered Fuel. Iron & Coal Trades Rev., vol. 113, no. 3052, Aug. 27, 1926, p. 296, 1 fig. Improved system at Gateshead Works of Clarke, Chapman & Co., England.

Boiler Firing. Pulverized Fuel Firing at a French Colliery, M. Sohm. Colliery Guardian, vol. 132, no. 3427, Sept. 3, 1926, p. 509, 3 figs. Details of installation at Bruay power station; in designing plant, chief objects were systematic removal of all dust from coal intended to be washed to facilitate washing operation and to prevent formation of slime; deduction of amount of labor in boiler house, at same time improving condition of boiler-house workers.

Central Stations. Influence of Pulverized-Coal Firing on the Design of Central Stations (Einfluss der Kohlenstaubfeuerung auf den Bau von Elektrizitätswerken), F. Münzinger. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 40 and 42, Oct. 2 and 16, 1926, pp. 1305–1310 and 1382–1388, 14 figs. Review of efforts already made to solve problems of design; special designs for steam boilers; behavior of cooled combustion chambers; radiation of gases and of glowing dust particles; suggestions for construction of inexpensive boilers with pulverized-coal furnaces; influence of air preheating; preparation; central stations with pulverized-coal firing; fuel economy.

Developments. Pulverized Fuel. Nat. Elec. Light Assn.—Report, no. 256–79, Aug. 1926, 78 pp., 64 figs. There has been continuing increase in number of stations adopting pulverized-fuel method of firing during past year and decided trend in direction of water-cooled furnace walls and elimination of refractories; there is still predominance of central preparation systems for large installations, but unit system is being given serious consideration for new installations; statements from 22 operating companies, including two industrial companies are given, and also statements from manufacturers of pulverized-fuel equipment; driers and drying methods; hydraulic ash sluices and development of turbulent burners. Bibliography. See abstract in Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1098–1100, 1 fig.

Making Electrical Drives Safe in Pulverized-Coal Plants, M. B. Wyman. Power, vol. 64, no. 14, Oct. 5, 1926, pp. 504–507, 7 figs. Methods used to eliminate explosion hazard in plants and how to select motors and controllers for these applications.

Low-Temperature Solid Residuals as. Low-Temperature Solid Residuals as Powdered Fuels, H. Nielsen. Iron & Coal Trades Rev., vol. 113, no. 3054, Sept. 10, 1926, pp. 384–386, 4 figs. Powdered distilled residue, provided that it is result of low-temperature distillation, where primary oil products have been subjected to slight, if any, cracking, burns as freely as powdered raw coal, if not more so; it occupies same volume, ton for ton, as that of raw coal; physical properties, specific gravities, moisture absorption and combustibility were for practical purposes identical.

Packing Plants. Pulverizing Coal in a Packing Plant, A. Murphy. Power House, vol. 20, no. 18, Sept. 20, 1926, pp. 21–23, 3 figs. Efficiency around 82 per cent obtained from pulverized-fuel equipment installed by Wm. Davies Co., Toronto, to lower cost of process steam; fuel saving of 1580 tons claimed from first 5 months' operation.

Pulverizers. The Clarke Chapman Turbo Pulverizer. Machy. Market, no. 1349, Sept. 10, 1926, pp. 25–26, 5 figs. Machine is so arranged that all wearing parts can be inspected and replaced in minimum amount of time; fan for primary air, which is integral part of machine, draws fine coal from separator and discharges coal and primary air direct to burners.

Schuckert-Petri System. Practical Results with Schuckert-Petri Combined Grate and Pulverized-Coal Firing (Betriebsergebnisse mit Kohlenstaubzusatzfeuerungen), K. d'Huart. Feuerungstechnik, vol. 14, no. 19, July 1, 1926, pp. 228–232, 7 figs. Results of tests with this system of firing.

Water Works, Use in. Use of Pulverized Fuel in the Water Works Plant, C. S. Denman. Am. Water Works Assn.—Jl., vol. 16, no. 3, Sept. 1926, pp. 296–301. Enumerates advantages of pulverized-coal firing. Bibliography.

PUMPING STATIONS

Automatic. Automatic Public Water Supply. Engineering, vol. 122, no. 3169, Oct. 8, 1926, pp. 454–455, 5 figs. First public water supply with automatic pumping plant in England, opened at Princes Risborough; plant consists of two sets of three-throw pumps, one driven by gasoline engine and other by electric motor, together with two cylindrical tanks.

PUMPS

Rotary. A New Conical Rotary Pump. Mech. World, vol. 80, 2073, Sept. 24, 1926, p. 239, 2 figs. Developed by A. G. Mumford, Ltd., Colchester, Eng.; it is known as Niagara pump and is intended for pumping oil fuel, brine, and for general work.

PYROMETERS

Radiation. Some Considerations on Radiation Pyrometers, A. J. Philpot. Sci. Instruments Jl., vol. 3, no. 11, Aug. 1926, pp. 366–373. Theoretical consideration of effect of varying distance from radiating source in total-radiation pyrometers of focusing and non-focusing lens and mirror types.

The Measurement of Combustion Chamber Temperatures, H. W. G. Westlake. Eng. & Boiler House Rev., vol. 40, no. 3, Sept. 1926, pp. 115–117, 4 figs. Describes radiation-type pyrometer.

R

RAILS

Wear. The Wear of Rails (Ein Beitrag zur Frage des Verschleisses der Eisenbahnschienen), A. Dormus. Stahl u. Eisen, vol. 46, no. 28, July 15, 1926, pp. 948–952. Based on experience on Arlberg and Meran-Bozen lines, it is shown that basic-steel rails having tensile strength of 88 kg. per sq. mm. were far more durable than different other types employed, having tensile strength of only 45 to 50 kg. per sq. mm.; these conclusions from actual service records are totally opposed to results obtained in series of abrasion tests made with Spindel machine, which author regards as evidence that values given by this machine bear no relation to abrasion resistance in service, and suggests explanation. See translated abstract in Metallurgist (Supp. to Engineer, vol. 142, no. 3689), Sept. 24, 1926, pp. 135–136.

RAILWAY ELECTRIFICATION

Austria. Electrification of Austrian Federal Railway (Elektrifikation der Oesterreichischen Bundesbahnen), A. Hruschka. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 49, 29 pp., 11 figs. System chosen corresponds to that employed in Germany, Switzerland, Sweden, and Norway, that is, generation and transmission of energy in form of single-phase alternating current of 55,000 volts and $16^2/_3$ cycles per sec., and feeding of trolley lines by means of transformer substations with 15,000 volts and same frequency; details of central stations and substations.

Developments. The Electrification of Railways, E. Huber-Stockar. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, Ee, 22 pp. Deals with electrification of railways by substituting electric for steam traction; cases arising in which electric traction is only possible solution from technical and economic point of view; nomenclature of data required for calculation of annual cost of operation of electric traction in relation to steam traction. English translation from German text.

France. Electrification of a Section of the Orleans Railway, H. Parodi. Instn. Elec. Engrs.—Jl., vol. 64, no. 357, Sept. 1926, pp. 893–908 and (discussion) 909–919, 24 figs. Discusses conditions which have led French Government to consider extensive electrification scheme, and explains general method adopted in drawing up scheme and utilizing in most economical manner sources of power available; particulars of power supply to Orléans Railway and rolling stock already in use and on order; design of electric locomotives and comparison between electric and steam locomotives.

Railway Electrification in France (Electrification des chemins de fer Francais), H. Parodi. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 43, 29 pp., 5 figs. In France, d.c. traction has been adopted in order to be able to use single three-phase distribution network for both traction and general power-supply purposes; results obtained by best electric locomotives as regards composition, weight and speed of trains are such as can not be realized by steam traction, which is clearly shown by electrified lines of Orléans and Midi Railways.

Paris Suburban. Paris Suburban Electrification, T. Rich. Elecn., vol. 97, no. 2520, Sept. 17, 1926, pp. 316–317, 8 figs. Details of cable and track system; avoiding ice troubles; third-rail insulations.

South Africa. The Natal Electrification. S. African Engr., vol. 16, no. 99, July 1926, pp. 3–11, 9 figs. Electrified section covers route mileage of 175 miles and track mileage of 309; it is largest electrification in world on 3-ft. 6-in. gage; details of work involved and of Colenso power station which is connected by 88,000-volt transmission lines with 11 substations; track mileage has been equipped with catenary system fed at 3000 volt from motor-generator sets in these substations.

Sweden. Electrification of the Stockholm-Gothenburg Line (Statsbaneelektrifieringen Stockholm-Göteborg), I. Oefverholm. Teknisk Tidskrift (Allmänna Avdelningen), vol. 56, no. 27, July 3, 1926, pp. 245–252, 17 figs. Details of monophase line; equipment of transformer stations, outdoor substations, overhead transmission line; 2-6-2 locomotives weighing 79.5 tons, etc.

Switzerland. Railway Electrification (Elektrifizierung der Eisenbahnen), E. Huber, H. Eggenberger, A. Dudler, H. Habich, K. Burlet, S. Schild, H. W. Schuler, F. Steiner and A. Jobin. World Power Conference, Sect. Basel Meeting, 1926—Advance Paper, no. 1, 83 pp., 14 figs. Survey of railway electrification in Switzerland with special attention to structures of Swiss Federal Railways, whose lines are being converted into electrical service; details of power stations, secondary stations, rolling stock; electrification of Federal Railways from economic point of view.

United States. Railroad Electrification, W. S. Murray. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 74, 14 pp. Compares development which in past 25 years has been made in United States in field of power transmission and railway electrification; whereas transmission of electric energy was standardized to 60 cycles 3-phase alternating current, nothing was done to make current system of five electric overland railways a uniform one; systems of some European countries are mentioned as means of comparison.

Virginia. Virginian Completes Electrification, E. I. Staples. Ry. Age, Sect. 1, vol. 81, no. 13, Sept. 25, 1926, pp. 540–542, 2 figs. Trains now hauled with electric power from Mullens, W. Va., 133 miles, to Roanoke, Va.; details of locomotives; operation of electrified zone.

RAILWAY MANAGEMENT

Purchasing. The C. M. & St. Paul Budgets Its Purchases. Ry. Age, vol. 81, no. 15, Oct. 9, 1926, pp. 665–669, 5 figs. Plan for budgeting purchases called allotment plan, whereby orders for material must be kept within predetermined amount each month; this allotment is fixed by chief purchasing officer and operates through general storekeeper and local storekeepers.

Statistics, Development of. Development of Railway Statistics with Special View of Economy in Operation. Int. Ry. Congress—Bul., vol. 8, nos. 9–10, Sept.–Oct. 1926, pp. 841–853. Discussion by sections; contains appendix giving statistics published annually by Italian State Railways in addition to statistics contained in annual report and monthly bulletins.

RAILWAY SHOPS

Labor-Saving Tools. Three Labor-Saving Tools from the Northern Pacific Shops, F. W. Curtis. Am. Mach., vol. 65, no. 16, Oct. 14, 1926, pp. 635–636, 9 figs. Gage for laying out tender trucks; combination head for turning and threading grease-cup plugs in radial drill; gear-driven attachment to air motor for reaming cylinder-flange holes.

RAILWAY TRACK

Gravity-Electric Power Units. The Sheremeteff Gravity-Electric Power Unit, J. A. Malan. Australasian Elec. Times, vol. 5, no. 7, July 27, 1926, pp. 493–494, 6 figs. Apparatus installed on Darling railway line, Melbourne, invented and patented by Russian railway engineer, by means of which power in form of gravity is obtained from passing rolling-stock wheels and stored up in raised weight; power thus obtained is controlled electrically, and can be used for operating points or signals or possibly other apparatus.

Joints. Track Joints and Their Maintenance. Ry. Age, Sect. 1, vol. 81, no. 13, Sept. 25, 1926, pp. 552–553. Length of track joints; kind of bolts and springs; installation and maintenance of joints. (Abstract.) Paper read before Roadmasters' & Maintenance of Way Assn.

REFRACTORIES

Foundry. Foundry Refractories, M. C. Booze. Fuels & Furnaces, vol. 4, no. 9, Sept. 1926, pp. 1071–1076. Discusses conditions imposed on refractories in foundry furnaces, namely, abrasion, flame impingement and expansion, and wall construction; insulation, effect of joints, wall thickness and heat capacity; specifications and method of testing.

Joint Committee on Foundry Refractories. Am. Foundrymen's Assn.—Advance Paper, no. 43, for mtg. Sept. 27–Oct. 1, 1926, 53 pp. Preliminary reports of subcommittees on survey of refractories in malleable steel and non-ferrous foundries.

Temperature Measurement. Temperature Measurement of Refractories during a Load Test (Die Temperaturmessung beim Druckerweichungsversuch an feuerfesten Baustoffen), W. Miehr. Tonindustrie-Zeitung, vol. 50, no. 32, Apr. 24, 1926, pp. 563–567, 4 figs. Softening temperature of same refractory varied from 1360 to 1403 deg. cent. depending upon methods used for measuring temperature.

REFRIGERANTS

Properties. Engineering Tables of Properties of New Refrigerants. Power, vol. 64, no. 14, Oct. 5, 1926, pp. 512–513. Tabular data on properties of butane, isobutane and propane.

REFRIGERATING MACHINES

Water-Vapor. Water-Vapour Refrigeration, W. W. O'Mahony. Ice & Cold Storage, vol. 29, no. 342, Sept. 1926, pp. 227–229, 3 figs. Details of new Follain machine with account of its application to industrial uses.

REFRIGERATING PLANTS

Corrosion. The Prevention and Retardation of Corrosion in Refrigerating Systems, N. B. Ornitzo Refrig. Eng., vol. 13, no. 2, Aug. 1926, pp. 64–65 and (discussion) 65–67. Calls attention to possible applications of results to specific problem of preventing or retarding corrosion in refrigerating systems; gives choice of structural materials from which to construct those parts of apparatus most susceptible to corrosion and possible methods that may be employed to retard or prevent corrosion in service.

RESEARCH

Engineering College and Industry. Research Relations Between Engineering Colleges and Industry, W. E. Wickenden. Am. Inst. Elec. Engrs.—Jl., vol. 45, no. 10, Oct. 1926, pp. 987–988. Points out that policy of concentrating resources in Europe has led to upbuilding of group of notable and distinctive research centers which are principal factor in attracting and holding to educational and research work outstanding authorities in several fields; results have been to give several institutions individuality quite unknown in United States.

ROLLING MILLS

Rolling, Theory and Practice of. The Theory and Practice of Rolling Steel, W. Tafel. Iron Trade Rev., vol. 79, nos. 2, 4, 6 and 8, July 8, 22, Aug. 5 and 19, 1926, pp. 76–79, 196–199, 313–315, 436–437 and 446, 22 figs. July 8: Rolled cast designs. July 22: Considerations to be used for so-called ornamental iron, which is type of periodic profile; complex profiles. Aug. 5: Power required for rolling; how to determine work; determination of relation of rolling passes to total working time. Aug. 19: Use of gas-steam engines for rolling-mill drive.

Seamless-Tube Manufacture. Make 50-Ft. Tubes From Ingots. Iron Age, vol. 118, no. 13, Sept. 23, 1926, pp. 846–850, 11 figs. Seamless-tube plant at Allenport, Pa., embraces one piercing mill and two pilger mills; reheating and polishing feature finishing operations.

ROPE DRIVE

Rope-Gripping Sheaves. The Development of Rope Gripping Sheaves with Special Regard to the Karlik Sheave (Die Entwicklung der Seilgreiferscheibe mit besonderer Berucksichtigung der Karlikschen Greiferscheibe), F. Marik. Fördertechnik u. Frachtverkehr, vol. 19, nos. 17, 18 and 19, Aug. 20, Sept. 3 and 17, 1926, pp. 256–258, 276–280 and 293–295, 26 figs. Calculation of driving power of rope-gripping sheave; advantages and disadvantages; comparison of drive with rope-gripping sheave and with smooth-grooved pulley; describes various systems, with special reference to Karlik type.

S

SAND, MOLDING

Clay Bond, Use of. Practical and Technical Data Obtained From the Use of Clay Bond in Molding Sand Heaps, R. F. Harrington, A. S. Wright and M. A. Hosmer. Am. Foundrymen's Assn.—Preprint no. 29, for mtg. Sept. 27–Oct. 1, 1926, 18 pp. Results of tests of use of clay bond; effects of different methods of mixing, such as hand, mulling, paddle wheel and automatic sand cutters; as result of investigations, clay is being used together with small percentage of new sand at plant with which author is connected, and saving of 60 per cent has been effected, to which must be added material saving in handling charges.

Control. Sand Control in the Foundry, H. W. Dietert and H. W. Wakefield, Jr. Am. Foundrymen's Assn.—Preprint no. 35, for mtg. Sept. 27–Oct. 1, 1926, 23 pp., 10 figs. Describes improvements in sand-control machines and developments in test practices of United States Radiator Corporation.

Grading. The Grading of Molding Sands, C. A. Hansen. Am. Foundrymen's Assn.—Preprint no. 3, for mtg. Sept. 27–Oct. 1, 1926, 30 pp., 8 figs. Analyzes and describes character of distribution of grain sizes in molding sands; proposes simple method of determining average fineness as basis for grading sands in respect to fineness of grain.

Metallurgical Control. Metallurgical Control of Foundry Sands, L. B. Thomas. Am. Foundrymen's Assn.—Advance Paper, no. 18, for mtg. Sept. 27–Oct. 1, 1926, 22 pp., 1 fig. Composition of molding sand with brief outline of chemical and physical properties; deals with five characteristics, namely: bond (clay), permeability, fineness, durability and refractoriness; method of grading sands by fineness tests; shop tests to determine durability and refractoriness of molding sands in conjunction with laboratory tests.

Mulling, Effect of. The Effect of Mulling on the Physical Properties of Foundry Sands, A. V. Leun. Am. Foundrymen's Assn.—Preprint no. 33, for mtg. Sept. 27–Oct. 1, 1926, 34 pp., 12 figs. Results of experiments to determine compressive strength, tensile strength, permeability and distribution.

Refractoriness. Some Experiments on the Refractoriness of Foundry Sands, D. W. Trainer, Jr. Am. Foundrymen's Assn.—Advance Paper, no. 27, for mtg. Sept. 27–Oct. 1, 1926, 19 pp., 5 figs. In first series of experiments described, two fixed factors were clay and sand, while percentages of clay added to sand were varied; mixtures were made into cones and fired in muffle; in next series of tests, bars of different sand-clay mixtures were made, and while supported at each end, were fired; degree of fusion was shown by bending of bars; further tests were made of natural molding sands and authors conclude that two distinct heat properties of sands should be recognized, namely, incipient fusion and complete fusion.

Strength. Strength Tests of Foundry Sands, T. C. Adams. Am. Foundrymen's Assn.—Advance Paper, no. 1, for mtg. Sept. 27–Oct. 1, 1916, 85 pp., 24 figs. Relation of strength tests to other foundry sand tests, principles to be observed in formulating standard strength tests and different problems encountered; different methods and apparatus for making strength tests; those treated are tensile, compressive and transverse tests (also shearing tests in one instance) of molding, core or other foundry sands.

SAW MILLS

Sweden. Modern Saw Mills with Automatic Sorting Plant (Neuzeitliches Sägewerk mit selbsttätiger Sortieranlage für Schnitthölzer), C. Schlegel. Maschinenbau, vol. 5, no. 18, Sept. 16, 1926, pp. 827–828, 3 figs. Design and operation; conveying arrangements for logs and cut timber, loading different sizes on different cars.

SEAPLANES

Low-Powered. Tests with Low-Powered Seaplanes (Versuche mit schwachmotorigen Wasserflugzeugen), W. v. Langsdorff. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 16, Aug. 28, 1926, pp. 335–336, 3 figs. Describes three designs of seaplanes with low-power engines, namely, Leyret- Le Prieur biplane with Anzani engine; Short Bros., Rochester, N. Y., a 2-seater with 2 Blackburne engines; and Daimler L 15-Wa, L 15 W, L 18 W and L 20 W; results of tests on Lake of Constance, Switzerland.

SHEET METAL

Galvanized, Bend Tests of. Bend Tests of Galvanized Sheet Steel, H. A. Stacy. Am. Inst. Min. & Met. Engrs.—Trans., no. 1600-C, for mtg. Oct. 1926, 35 pp., 22 figs. Results of series of tests; study of tabulated results and curves show that for substantial proportion of all sheets, there were few specimens showing bend failure with high mandrel thickness; curves, as a rule, show fairly uniform gradient up to 90 per cent point.

SHERARDIZING

Electric. Electro-Sherardizing. Nat. Elec. Light Assn.—Report, no. 256-85, Aug. 1926, 4 pp., 2 figs. Consists of covering iron or steel with protective coating by revolving material in drums in zinc-dust preparation maintained at temperature of approximately 375 to 400 deg. cent. by means of electric heat; data on electric sherardizing.

SILK

Artificial. Manufacture of Artificial Silk (La fabrication de la soie artificielle), A. Guillaumin. Technique Moderne, vol. 18, no. 18, Sept. 15, 1926, pp. 545–551, 16 figs. Principle of viscose production; preparation, grinding, ripening of alkaline cellulose; scanthogenate; purification of viscose, etc.; and apparatus used.

SLAG

Open-Hearth. Open Hearth Slags, W. C. Hamilton. Am. Foundrymen's Assn.—Advance Paper, no. 7, for mtg. Sept. 27–Oct. 1, 1926, 11 pp. Discusses acid and basic slags, their function, composition and control; particular attention is paid to limestone, dolomite and use of fluorspar.

SMOKE ABATEMENT

Smokeless Heat and Power Production. Smokeless Production of Heat and Power, M. Fishenden. Gas J., vol. 175, no. 3304, Sept. 15, 1926, pp. 606–608. Discusses various systems of carbonization; coal liquefaction and conversion of water gas produced from coke into liquid fuels; gas and electric cooking and heating; gas coke for household use; coal blending. Paper presented before Smoke Abatement Conference.

SOLDERS

Electrically Heated. Electrically Heated Lead, Solder and Babbitt Pots. Nat. Elec. Light Assn.—Report, no. 256-90, Aug. 1926, 7 pp., 3 figs. Sizes and types considered; electrical rating of pot; babbitting motor bearings.

STANDARDIZATION

Engineering Aspects. Some Engineering Aspects of Standardization, E. G. Bern. Gen. Elec. Rev., vol. 29, no. 10, Oct. 1926, pp. 736–741, 6 figs. Standardization promotes production; hardware parts, manufactured parts, component unit mechanisms and their representation; determination of size of steps in line of products; creating harmonious whole.

Textile Industry. Standardization in the Textile Industry (Standardisering inom textilindustrien), A. Engblom. Teknisk Tidskrift (Allmanna Avdelningen), vol. 56, no. 25, June 19, 1926, pp. 230–233. Discusses standardized methods of investigation, processes and equipment, nomenclature, dimensions and quality.

STANDARDS

Introducing. Best Ways to Introduce Standards, L. F. Swenson. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 261–262, 2 figs. Points out that separate division or department should be created for purpose; personnel of Standards Division should be technically trained men; to make standards information available throughout plant tracing of standard sheets should be made.

STAYBOLTS

Special Steels for. Locomotive Fire-box Stay Bolts. Metallurgist (Supp. to Engineer, vol. 142, no. 3689), Sept. 24, 1926, pp. 141–142. Refers to experiment recently carried out on Detroit, Toledo & Ironton R. R. of Henry Ford, making use of alloy steel containing 0.10 to 0.14 per cent of carbon and 0.25 to 0.35 per cent of chromium; apparently these bolts have successfully resisted corrosion and erosion on flame side; success of American experiment would suggest trial of one or other of new steels for staybolt purposes.

STEAM

High-Pressure. Higher Steam Pressures and Temperatures. Nat. Elec. Light Assn.—Report, no. 256-77, July 1926, 8 pp., 5 figs. Data from plants employing high-pressure or high-temperature steam cycle have been tabulated in such form that heat consumption of these plants can be analyzed; gives curves showing behavior of metal under prolonged stress at high temperature.

Specific Heat. Research on the Specific Heat of Steam (Die Arbeiten des Laboratoriums fur technische Physik in Munchen zur Erforschung der spezifischen Warme des Wasserdampfes), Schmolke. Warme, vol. 49, no. 32, Aug. 6, 1926, pp. 563–565. Summary of investigations conducted in Laboratory for Technical Physics in Munich during past 20 years under direction of O. Knoblauch; reference is made to work of other investigators, and physical relationships successively established are summarized.

STEAM ACCUMULATORS

Ruths. The Use of the Ruths Accumulator in Parallel Operation of Hydroelectric and Steam Plants (Die Verwendung des Ruthsspeichers beim Zusammenarbeiten von Wasserkraft und Dampfkraft), J. Ruths. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 34, 20 pp., 10 figs. Ruths accumulator is medium for cheap generation of shorter peak loads; describes two installations of this kind erected in Sweden at Malmö and Halmstad; in both cases accumulator levels load of boiler and serves as momentary reserve as well; both installations have given satisfactory service; another field of application is for large hydroelectric systems where steam power is mainly used for covering peak loads.

Textile Mills. Steam Accumulator in Textile Mills, C. L. Hubbard. Textile World, vol. 70, no. 10, Sept. 4, 1926, pp. 69–72, 13 figs. Fluctuation of demand for process steam causes low load factor on boilers and waste of exhaust steam; principle and construction of Ruths steam accumulator; method of control; determining required storage capacity; effect on cost of plants; application to textile mills.

Uses of. Smoothing Out the Load with a Steam Accumulator, A. A. Potter and M. J. Zucrow. Power, vol. 64, no. 15, Oct. 12, 1926, pp. 554–556, 3 figs. Constant boiler load with variable steam demand extends boiler capacity, improves efficiency and opens way to use of inferior fuels.

STEAM ENGINES

High-Speed. Recent Steam Engines (Neuzeitliche Dampfmaschinen), A. Kriegbaum. Warme- u. Kälte-Technik, vol. 28, no. 18, Sept. 8, 1926, pp. 207–209, 6 figs. Describes trip-gear machine making 350 r.p.m. and working smoothly and entirely satisfactorily; special trip gear developed by Sächsische Maschinenfabrik.

STEAM PIPES

Distribution Lines. Steam Distribution Lines at Rochester, E. R. Benedict. Power Plant Eng., vol. 30, no. 19, Oct. 1, 1926, pp. 1067–1070, 5 figs. Construction operations involved in furnishing city with heat from central station.

High-Pressure. Long Steam Line Efficient at High Pressure, R. H. Baker. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1095–1097, 5 figs. Steam equivalent to 10,000 kw. delivered at 163 lb. through 4500-ft. line with 3 per cent loss.

STEAM POWER PLANTS

Developments. Modern Steam Generation, J. D. Troup. Int. Sugar Jl., vol. 28, nos. 327, 328, 329 and 333, Mar., Apr., May and Sept. 1926, pp. 133–136, 188–191, 240–244 and 459–462, 3 figs. Developments in water-tube boilers, furnace design and stoking, air preheating, boiler pressures, increasing furnace temperature. Apr.: Feedwater; steam accumulator. May: Boiler-house control. Sept.: Maintaining clean heating surfaces; steam-jet principle; soot blowers; pneumatic system.

Recent Developments as Affecting Design and Construction of Power Plants, W. P. Gavit. Elec. World, vol. 88, no. 13, Sept. 25, 1926, pp. 623–627, 10 figs. Points out that reheating, regeneration, preheating and burning of pulverized coal have, except for last, not imposed large changes in practices of power-house design and construction.

Fuel Economy. How to Cut 14 Per Cent From the Power Bill, W. A. Shoudy. Mfg. Industries, vol. 12, no. 4, Oct. 1926, pp. 273–276, 4 figs. Points out that a few simple, inexpensive instruments and an intelligent fireman will assist effectively in reducing fuel consumption.

The Use and Abuse of Fuel in the Industrial Power Plant, F. H. Daniels. Engrs. & Eng., vol. 43, no. 9, Sept. 15, 1926, pp. 233–237. Characteristics of coal and sizing; suggestions for coal saving; improvement due to stokers; type of stokers; pulverized coal versus stokers; comparison of pulverized-coal equipment and stokers.

Mixed-Pressure. Mixed-Pressure Steam Power Plants (Beitrag zum gemischten Dampfkraftbetrieb), R. Nitzschmann. Feuerungstechnik, vol. 14, nos. 19, 20 and 21, July 1, 15 and Aug. 1, 1926, pp. 225–228, 237–242 and 249–253, 18 figs. Relation between steam and power plant; investigation of influence of flue-gas and waste-heat utilization with economizer, waste-heat boiler and air preheating; supplementary heating of feedwater with bleeder steam; derivation of a simple turbine formula; economic treatment of problem.

STEAM TURBINES

Developments. Steam Turbine Development Since 1900, C. C. Brown. Power Plant Eng., vol. 30, no. 20, Oct. 15, 1926, pp. 1106–1107, 2 figs. Sets forth graphically trend of steam-turbine development from standpoint of steam economy, steam temperatures and pressures, and unit capacities, as experienced in actual operation of number of plants which were installed in various years; also daily fuel-oil consumption for two Western steam-generating plants.

Turbines. Nat. Elec. Light Assn.—Report, no. 25-103, Dec. 1925, 52 pp., 64 figs. Characteristics of outstanding turbine installations made during past year; evaluation of present-day tendencies in design; indicates possibility of modifying existing turbine designs in order to obtain higher ratings; operation of turbines in Philo Station and of mercury-vapor turbines in Dutch Point Station at Hartford, Conn.; operating history of 8 large turbines installed in Paris, France, result of water-rate tests being given for one of 40,000-kw. turbines installed in Gennevilliers station; water-rate tests conducted in connection with 12 large turbines, ranging from 20,000-kw. to 45,000-kw. capacity. Bibliography.

15,000-Kw. Test of 15,000-Kw. Turbine at the Cleveland Municipal Plant, L. A. Quayle. Power, vol. 64, no. 16, Oct. 19, 1926, pp. 583–585, 6 figs. With steam at moderate initial pressure and temperature, this turbine shows good results after six months of regular operation; full-load water rate, 11.34 lb. per kw-hr.

High-Pressure. The Use of High Pressures for Steam Turbine Installations, S. S. Cook. Nature (Lond.), vol. 118, no. 2969, Sept. 25, 1926, pp. 450–452, 1 fig. Presents diagram exhibiting shortcomings of Rankine cycle in comparison with ideal Carnot cycle, and points out that similar departures from ideal are present in any type of engine in practical use; shows that not only high temperatures, as in case of adoption of high superheat, but also high boiler pressures, lead to substantial increase in overall thermal efficiency.

Impulse Reaction. 20,000-K. W. Impulse Reaction Turbine at Bradford. Engineering, vol. 122, no. 3170, Oct. 15, 1926, pp. 465–469, 38 figs. partly on supp. plates. Constructed by English Electric Co.; remarkable compactness of set is illustrated by fact that it takes up slightly less floor space than 1000-kw. reciprocator set which it replaces, and yields 35 kw. for each square foot of area occupied; high-pressure section, which develops 60 per cent of total output is constructed on impulse system, while low-pressure turbine is double-flow reaction machine differing merely in detail from standard practice.

STEEL

Corrosion. Tests as to Exact Determination of Corrosion of Steels by Chemical Reagents (Versuche über die genaue Bestimmung der Korrosion durch chemische Agentien an Stählen), V. Duffek. Korrosion und Metallschutz, vol. 2, no. 6, June 1926, pp. 149–152, 3 figs. Method depending on reduction in weight of steel when suspended in acids for 24 hours, passivity of steel; effect of surface conditions on velocity of dissolution.

Fatigue Tests. Some Comparative Fatigue Tests in Special Relation to the Impressed Conditions of Test, H. J. Gough and H. J. Tapsell. Aeronautical Research Committee—Reports and Memoranda, no. 1012, Apr. 1926, 21 pp. Results of lengthy series of endurance tests on two steels adopted by Aeronautical Research Committee as standard material for comparative tests by various investigators; it is shown that varying results obtained cannot be reconciled on any simple basis, such as criterion of limiting shear stress.

Hardness. A Further Study of the Distribution of Hardness in Quenched Carbon Steels, and Quenching Cracks, T. Kasé. Tohoku Imperial Univ.—Sci. Reports, vol. 15, no. 3, July 1926, pp. 371–386, 21 figs. Investigation of distribution of hardness in carbon steels, which had been quenched, or quenched and immersed in liquid air, hardness measurement being made by means of Shore's scleroscope. (In English.)

STEEL CASTINGS

Converter Process. Some Physical Properties and Composition of Cast Converter Steel; C. M. Campbell. Am. Foundrymen's Assn.—Preprint no. 37, for mtg. Sept. 27–Oct. 1, 1926, 6 pp. Author presents tension-test figures and composition of several heats of cast carbon steel made by converter process; calls attention to high ductility obtained from test bars "as cast" and in annealed condition, also close limits within which it is possible to hold composition of various kinds of carbon steels; discusses low limits within which it is possible to hold sulphur in converter.

Defects. Defects in Steel Castings Discovered After Shipment from the Foundry, J. M. Sampson. Am. Foundrymen's Assn.—Preprint no. 41, for mtg. Sept. 27–Oct. 1, 1926, 23 pp., 11 figs. Analysis of discounts in steel foundry and particularly of rejections and salvaging work in machine shops.

Defects in Steel Castings in the Foundry, R. S. Munson. Am. Foundrymen's Assn.—Preprint no. 38, for mtg. Sept. 27–Oct. 1, 1926, 8 pp. Discusses only defects which are evident in foundry during manufacture; generally speaking, causes of defects can be placed under three main heads: design and pattern equipment, molding and core-shop methods, and melting and pouring conditions.

Manganese in. Manganese in Cast Steels, J. H. Hall. Am. Foundrymen's Assn.—Preprint no. 40, for mtg. Sept. 27–Oct. 1, 1926, 16 pp., 4 figs. In author's opinion, results of tests fully justify opinion that heat-treated cast steels containing from .20 per cent to .30 per cent carbon, and manganese from 1 to 2 per cent, possess remarkable combination of properties that makes them of greatest value for severe service in machine parts.

STEEL, HEAT TREATMENT OF

Annealing The Heat Treatment of Steel, H. M. Boylston. Fuels & Furnaces, vol. 4, no. 9, Sept. 1926, pp. 1035–1066, 22 figs. Annealing of forged or rolled carbon-steel objects, of cold-worked objects, steel castings, and tool steel, high-speed steel and special steels; furnaces for annealing; toughening treatments, hardening, tempering, carburizing and case-hardening; heat treatment of case-hardened objects.

Ferro-Carbon-Titanium. Treatment of Steel with Ferro-Carbon-Titanium, G. F. Comstock. Foundry Trade Jl., vol. 34, no. 524, Sept. 2, 1926, pp. 205–207. Shows what is being done with ferro-carbon-titanium at present time and gives outline of practical results obtained by its use; use of titanium in steel for sand castings; value of ferro-carbon-titanium lies in its being good deoxidizer; more powerful qualitatively than silicon and one that does not make steel dirty when used; it is essentially gray cast iron containing titanium-carbide, as well as some dissolved titanium, and is made in electric-arc furnace by reduction of oxide ore with carbon. Paper read before Stockholm meeting of Iron & Steel Inst.

STEEL MANUFACTURE

Improvement of Methods. The Quality of Steel and Its Relations to Production Method (Ueber Stahlqualitäten und ihre Beziehungen zu den Herstellverfahren), P. Goerens. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 33, 34 and 36, Aug. 14, 21 and Sept. 4, 1926, pp. 1093–1099, 1129–1136 and 1194–1198, 31 figs. What is understood by quality; non-metallic inclusions in steel, their detection and significance; present methods of manufacturing steel, their advantages and disadvantages; prospects of improving methods; necessity of close coöperation between consumers and producers.

T

TERMINALS, LOCOMOTIVE

Roundhouses. An Effective Combination of New and Old Roundhouses. Ry. Age, vol. 81, no. 14, Oct.

2, 1926, pp. 623–628, 7 figs. Chesapeake & Ohio increases capacity of engine terminal at Russell, Ky.; by combining new facilities with old without committing plan for new facilities to any objectionable features in consequence of efforts to continue use of major portion of old plant; new roundhouse is served by independent approach layout; shop building occupies space between two roundhouses; mechanical equipment for handling coal is unique; storehouse facilities.

Turntables. New Turntables of the Dutch Railways (Mededeelingen omtrent de nieuwe draaischijven bij de Nederlandsche Spoorwegen), W. Mundt. Ingenieur, vol. 41, no. 32, Aug. 7, 1926, pp. 665–668, 4 figs. Describes Vögele and Eschweiler types of turntables of 20 m. diameter; a.c. motor drive.

TESTING MACHINES

Metal-Working Industry. Testing Plants in the Metal-Working Industry (Prüfanlagen für die Metallbearbeitungs-Industrie), K. Meller. Siemens-Zeit., vol. 6, nos. 6, 7, and 8, June, July and Aug., 1926, pp. 297–304, 343–348, and 385–391, 31 figs. Details of plants and methods for testing stationary gasoline Diesel engines, machine tools, etc.; gas producers, automobiles, sewing machines, pumps, machine-tool drives, etc.

TEXTILE MILLS

Thermal Efficiency. Thermal Efficiency in Textile Mills (Wärmewirtschaftliche Hinweise für Textilbetriebe), H. Mittermayr. Wärme, vol. 49, no. 30, July 23, 1926, pp. 527–531, 3 figs.; also translated abstract in Eng. & Boiler House Rev., vol. 40, no. 3, Sept. 1926, p. 144. Deals with basis factors governing kind and size of power plant for textile mills, selection and supervision of equipment, and economical handling of wide fluctuations in consumption, especially in dyeing; diagrams can be prepared showing heat and power requirements of individual machines, and much can be done to equalize demand by adjusting working periods so as to avoid peak loads; in places where heating requirements are relatively small, condensing engine is most economical; for combined spinning and weaving, larger requirements for heating may be met by extracting partially expanded steam; where steam-heating requirements are very large, it is best to use back pressure, single-cylinder-engine being preferable.

TEXTILES

Viscose Finish. Viscose as a Textile Finish, E. H. Morse. Textile World, vol. 70, no. 13, Sept. 25, 1926, pp. 37–39, 1 fig. Varieties of finishes possible with viscose; résumé of work done in experiments with this regenerated cellulose; what viscose is and how it is manufactured; machinery used and intermediate products formed in manufacture; warnings to prospective manufacturers.

THERMOMETERS

Developments. Thermometry, W. F. Higgins. Roy. Soc. of Arts—Jl., vol. 74, nos. 3850, 3851 and 3852, Sept. 3, 10 and 17, 1926, pp. 946–959, 962–975 and 978–986, 16 figs. Sept. 3: Consideration of historical aspect for purpose of tracing evolution of thermometer from early types to modern instrument; introduction of mercury thermometers; pressure corrections; scales of temperatures. Sept. 10: Principal types of thermometric glass used at present time; consideration of types of zero variation; typical specification for thermometer. Sept. 17: Method of obtaining greatest accuracy in use of mercury thermometer; question of thermometric lag; comparison of thermometers with standard instruments.

Remote-Control. Distance Control Thermometers (Les Thermomètres à distance), L. Poincaré. Aéronautique, vol. 8, no. 88, Sept. 1926, pp. 300–304, 6 figs. Principle of Chenu and Fournier types of thermometers based on measuring vapor tension of volatile liquid; Aera thermometer, design and operation.

TIDAL POWER

Passamaquoddy Project. Some Aspects of the Passamaquoddy Tidal Power Project, D. S. Cooper. Conn. Soc. of Civ. Engrs.—Trans., 1926, pp. 29–34 and (discussion) 34–36. Power development is located in Maine near Eastport, and contemplates construction of modern low-head hydroelectric station using tides as source of water supply.

Utilization. Using Tides and Ocean Waves for Electric Power Production (Ausnützung der Gezeiten und Meereswogen zur elektrischen Energieerzeugung), W. Meyer. Elektrotechnischer Anzieger, vol. 43, nos. 64 and 65, Aug. 11 and 14, 1926, pp. 719–721 and 729–730. Severn (England) and Vraach (France) projects; single-basin and double-basin system; compressed air and electricity as means for equalizing fluctuations in energy. Bibliography.

TIME STUDY

Piece-Rate Calculation. Time Control and Piece-Rate Calculation (Zeitkontrolle und Vorkalkulation), Maschinenbau, vol. 5, no. 17, Sept. 2, 1926, pp. 789–792, 7 figs. Advocates separate booking of each operation as prerequisite to precalculation (piece-rate calculation); describes Lüer system of wages cards and their application.

TIRES, RUBBER

Endurance Tests. Endurance Tests of Tires, W. L. Holt and P. L. Wormeley. U. S. Bur. Standards—Technologic Papers, vol. 20, no. 318, May 25, 1926, pp. 545–551, 3 figs. Test results of 3½, 4, 4½ and 5-inch cord tires (230 tires of 36 different brands); describes two types of endurance-test machines installed at Bureau of Standards.

TOOLS

Straight-Form. Considerations Governing the Design of Straight Form Tools with Top Rake, F. Parks. Machy. (Lond.), vol. 28, no. 725, Sept. 2, 1926, pp. 651–653, 3 figs. Recent investigations have resulted in development of formulas which are original as far as author is aware.

TRACTORS

Industrial and Farm. Industrial and Farm Tractors (Motorschlepper für Industrie und Landwirtschaft), G. Becker. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 37 and 38, Sept. 11 and 18, 1926, pp. 1209–1214 and 1261–1263, 23 figs. Comparison of effective tractive effort on the field and on road; influence of arrangement of drive with wheel and caterpillar tractors; speed and road stresses; details of design; efficiency, fuel consumption and wear of engines.

TRANSPORTATION

Road-Rail System. The Auto-Rail System (Das "Autobahn" System), L. Tlaskal. Verkehrstechnik, vol. 39, no. 33, Aug. 13, 1926, pp. 523–526, 3 figs. Describes system which combines highway and rail transportation; ordinary motor truck is mounted on field-railway truck, its back wheels running on road on either side of track; a great tractive force is developed due to friction of rubber tires; front part of motor truck and all the trailer cars roll on light cheap rails with saving of tractive effort. System effects saving in freight transportation and economic development of traffic-poor districts; in soft soil (forests and fields), caterpillar tractor is used in place of motor truck.

W

WAGES

Systems. Wage Problems with Conveyorized Work (Lohnfragen bei Fliessarbeit), W. Schlachter. Maschinenbau, vol. 5, no. 12, June 17, 1926, pp. 573–578, 2 figs. Simple piece work is criticized because it gives too high wages when great reductions of time are secured and same is true of premium system, granting for instance premium of one third of time saved; better system consists in paying worker 0.6 per cent bonus for every 1 per cent of time saved; only difficulty with this system is that worker as a rule cannot figure out for himself how much he should get for given amount of work; charts showing this should be posted in factory; in case of conveyorized work, group piece rates may be worked out, but it is usually better to pay by hour and give group premiums when certain task is done in less than standard time. See brief translated abstract in Automotive Abstracts, vol. 4, no. 9, Sept. 20, 1926, p. 283.

WATER METERS

Manufacture. Making Meters to Record Flow of Water, A. Murphy. Power House, vol. 20, no. 18, Sept. 20, 1926, pp. 27–31, 11 figs. Meters made by National Meter Co. of Canada at their Toronto plant are of positive-displacement oscillating-piston type; such meters with suitable modifications will also measure other liquids such as oils and gasoline.

WATER POWER

Inland Navigation and. Relation Between Water-Power Utilization and Inland Navigation (Die Beziehungen zwischen der Wasserkraftausnutzung und der Binnenschiffahrt), Höbel. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 24, 13 pp. Points out that it is possible, in many instances, that conflicts of interests between two systems may arise; these can, however, be so regulated as to mitigate them considerably; power stations in canalized rivers require long maintenance of useful fall during high water, frost and during dock repair periods; in order to prevent clogging of turbine gratings, ice cover is thought desirable; this, however, is detrimental to navigation; in order to reduce detrimental water losses to minimum, it is desirable to subdivide navigation locks into large and small chambers to reduce water consumption through locking as far as possible.

Utilization of Water Power & Inland Navigation, H. L. Cooper. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 75, 11 pp., 28 figs. Describes Wilson dam in Tennessee River at Muscle Shoals; it drains watershed of 30,600 sq. mi.; second dam, 30 miles below Wilson dam will raise natural water level 40 ft.; thus 600,000 hp. will be obtained; all structures are founded on solid rock and most of them are of mass concrete; reference also to St. Lawrence River Navigation and Power Proposal; river has catchment basin of 200,000 sq. mi., 90,000 sq. mil. of which are lakes; project is now before governments of Canada and United States.

National Aspects. National Aspects of the Study of Water Resources, N. C. Grover. World Power Conference, Sect. Basel Mtg., 1926—Advance Paper, no. 72, 17 pp., 15 figs. Points out that study and investigation of existing water-power resources is problem of great importance for all countries, particularly for arid or semi-arid countries which have to be irrigated; this is case in some western districts of United States; water measurements and gaging stations are discussed.

Utilization. International Exhibition for Inland Navigation and Water-Power Utilization at Basel (Switzerland) (Internationale Ausstellung für Binnenschiffahrt und Wasserkraftnutzung in Basel), Seifert. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 40, Oct. 2, 1926, pp. 1311–1316. Improvement of the Upper Rhine; exhibits relating to inland navigation and hydroelectric plants; experimental stations and measuring instruments.

Valuation. Some Fallacies in the Valuation of Water Power, A. D. Adams. Eng. News-Rec., vol. 97, no. 12, Sept. 16, 1926, pp. 470–471. Some of contentions frequently made in court to increase award of damage for diverted water.

WELDING

Applications. Modern Welding Methods (Neuere Schweissverfahren und Gestaltung), W. Strelow. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 40, Oct. 2, 1926, pp. 1317–1323, 19 figs. Comparison of welded and riveted joints and their strength properties, based on experiments and practical experience; examples are given showing applications of welding to building construction, tank construction, shipbuilding, car and machine construction, and resulting simplifications in design.

Electric. See ELECTRIC WELDING; ELECTRIC WELDING, ARC.

Jigs and Fixtures. Saving Money by Welding Jigs and Fixtures, R. E. Kinkead. Am. Mach., vol. 65, no. 18, Oct. 28, 1926, pp. 707–708, 7 figs. Both time and expense of making patterns can be saved and cheaper material can be used in body of fixture.

Locomotive Parts. Welding of Locomotive Parts by the Oxyacetylene, Electric, and Thermit Processes, G. H. Gjertsen. Am. Welding Soc.—Jl., vol. 5, no. 10, Oct. 1926, pp. 22–29, 8 figs. In railway work, thermit is almost entirely limited to welding of engine frames, whereas oxyacetylene and electric arc cover much the same field in welding of many of steel parts.

Organization, Railways. The Organization of Welding on the Railroads, F. H. Williams. Am. Welding Soc.—Jl., vol. 5, no. 10, Oct. 1926, pp. 29–60. Gives organization of welding and general practice followed on Canadian National Railways, which for most part was practice on most of American railways; economies affected by use of thermit, oxyacetylene and electric welding processes; maintenance regulation; welding rods and flux; welding and cutting in connection with boiler work; specifications.

Pipe Lines in Buildings. Welding Pipe Lines in Buildings, H. E. Wetzell. Welding Engr., vol. 11, no. 9, Sept. 1926, pp. 34–38, 4 figs. Points out that welding can make possible saving as great as $40 on single joint.

Refrigerating Equipment. Welding of Refrigeration Equipment, W. F. Schaphorst. Ice & Refrigeration, vol. 71, no. 3, Sept. 1926, pp. 177–178, 4 figs. Author suggests that caution should be observed before plunging into electric or gas welding too promiscuously; describes so-called intermittent system of refrigeration and presents graph showing how three generators operated; illustrations of welded vessels.

University Curricula. Welding Science in the Engineering Curriculum of Universities. Am. Welding Soc.—Jl., vol. 5, no. 10, Oct. 1926, pp. 8–19. Contains three articles by S. T. Hart, O. L. Rickly and W. P. Turner, respectively, telling what is being done in American universities to study science of welding and what they have in mind to do in near future.

WINDMILLS

Aerodynamics of. Aerodynamics of Windmills (Sur l'aérodynamique des moulins à vent), M. Amans. Académie des Sciences—Comptes Rendus, vol. 182, no. 13, Mar. 29, 1926, pp. 841–843. Experiments on effect of inclination of wind stream and of blade twist on performance of screws, with particular reference to windmill vanes.

Holland. The Dutch Mill Problem (De Hollandsche molen en de Windbemaling), J. J. Stieltjes. Ingenieur, vol. 41, nos. 21, 22 and 30, May 22, 29 and July 24, 1926, pp. 409–413, 437–441 and 616–632, 13 figs. A discussion by Dutch Institute of Engineers, covering esthetics; drainage of polders by windmills; cost of installation and operation; electricity vs. windmills; possibilities of improving windmills. Includes discussion.

WIRE ROPE

Care and Maintenance. Care and Maintenance of Wire Rope. Foundry, vol. 54, nos. 19 and 20, Oct. 1 and 15, 1926, supp. sheets. How to measure wire rope; lubrication. Oct. 1: Foundry data sheet. Oct. 15: How to seize wire rope.

How, When, and Why of Wire Rope, W. Voigtlander. Min. & Met., vol. 7, no. 237, Sept. 1926, pp. 389–392, 6 figs. Presents useful hints on care of ropes.

WOOD

Plywood. Plywood in Trade and Industry (Sperrholz für Handwerk und Industrie), L. M. Cohn-Wegner. Gewerbefleiss, vol. 105, no. 8, Aug. 1926, pp. 165–186, 17 figs. Discusses treatment of veneers, sawed, sliced, cut; production of plywood and machinery used; use in construction of airships, for frames, screws, etc.; for producing hollow vessels, etc.

WOOD PRESERVATION

Problems. Wood Preservation and the Engineer, R. W. Smith. Military Engr., vol. 18, no. 100, July–Aug. 1926, pp. 311–313, 5 figs. Most important property of wood preservative is that it be toxic to decay-producing organisms and wood borers; wood-preserving plants and what they consist of; treatment of railway ties, transmission-line poles, mine timber, etc.

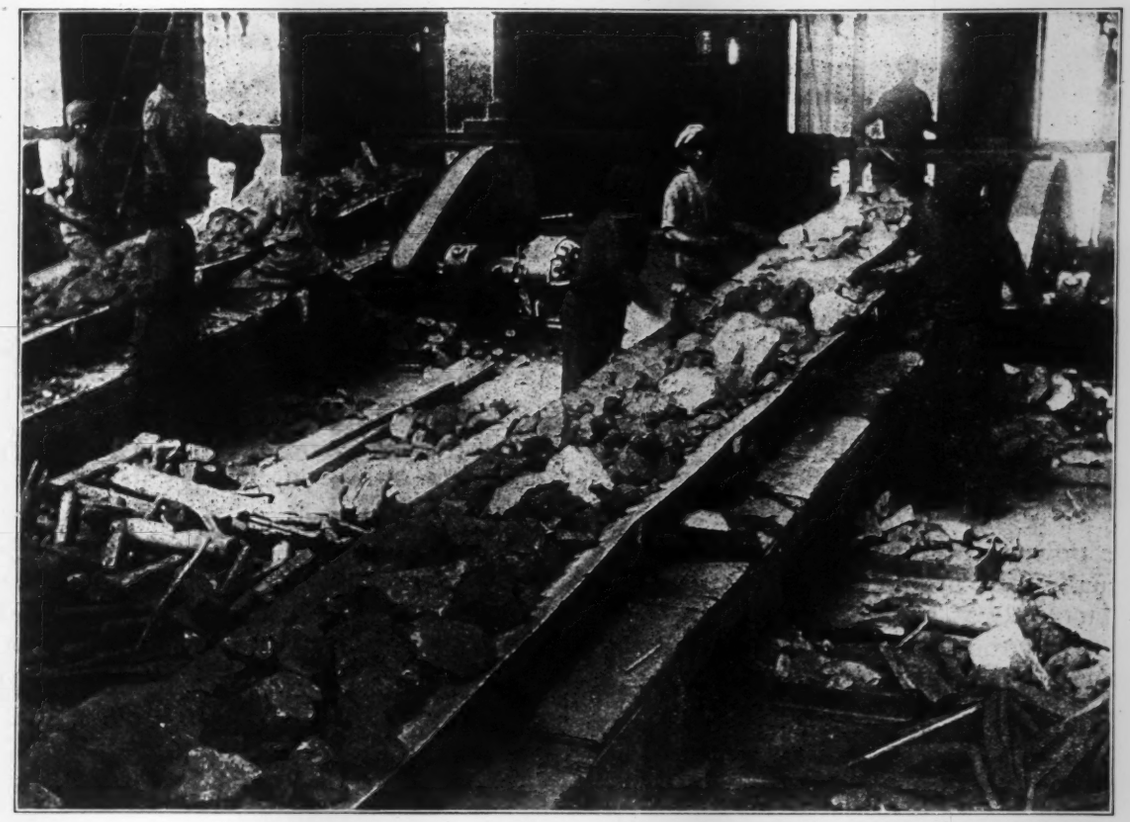
WOODWORKING MACHINERY

Log Frames. High-Speed Log Frames. Engineer, vol. 142, no. 3689, Sept. 24, 1926, p. 344, 1 fig. Frames, built by A. Ransome & Co., Newark-on-Trent, intended for cutting up soft wood logs.

Millers. Wadkin "Semi-Auto" Universal Wood Miller. Am. Mach., vol. 65, no. 16, Oct. 14, 1926, pp. 651–652, 1 fig. Machine manufactured in England is particularly adapted for pattern work; all its motions are underhand and power control, and it is fitted with scales and micrometer feeds to facilitate production of accurate surfaces.

WOOL

Artificial Manufacture. Artificial Wool Manufacture, H. Drexler. Paper Trade Jl., vol. 83, no. 13, Sept. 23, 1926, pp. 47–48. Discusses production of new fiber, named artificial wool, which, in appearance closely resembles natural wool; developed by Italian firm, Snia Viscosa; it is claimed that new product is easy to dye; Xanthogenate process is probably used.



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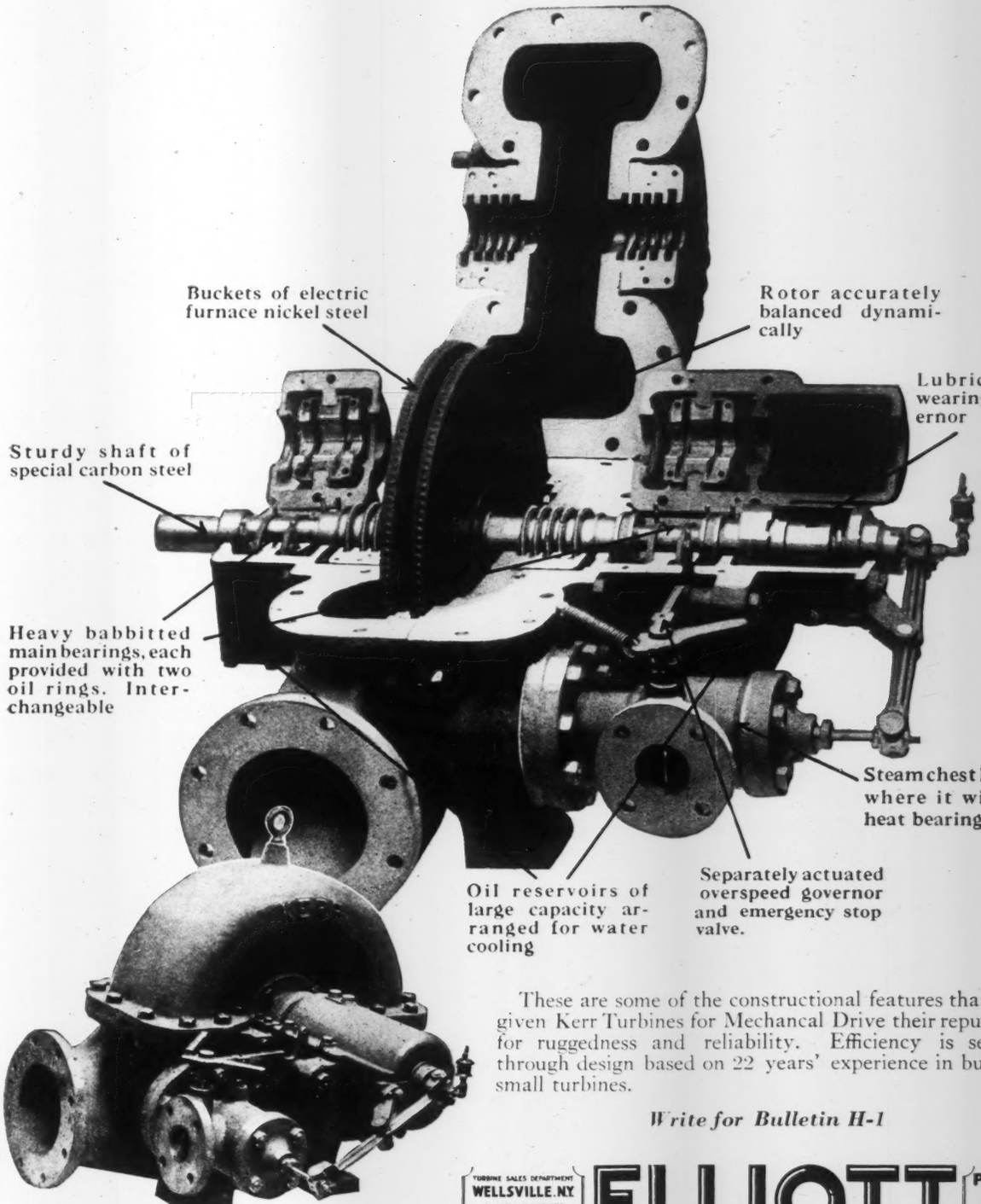

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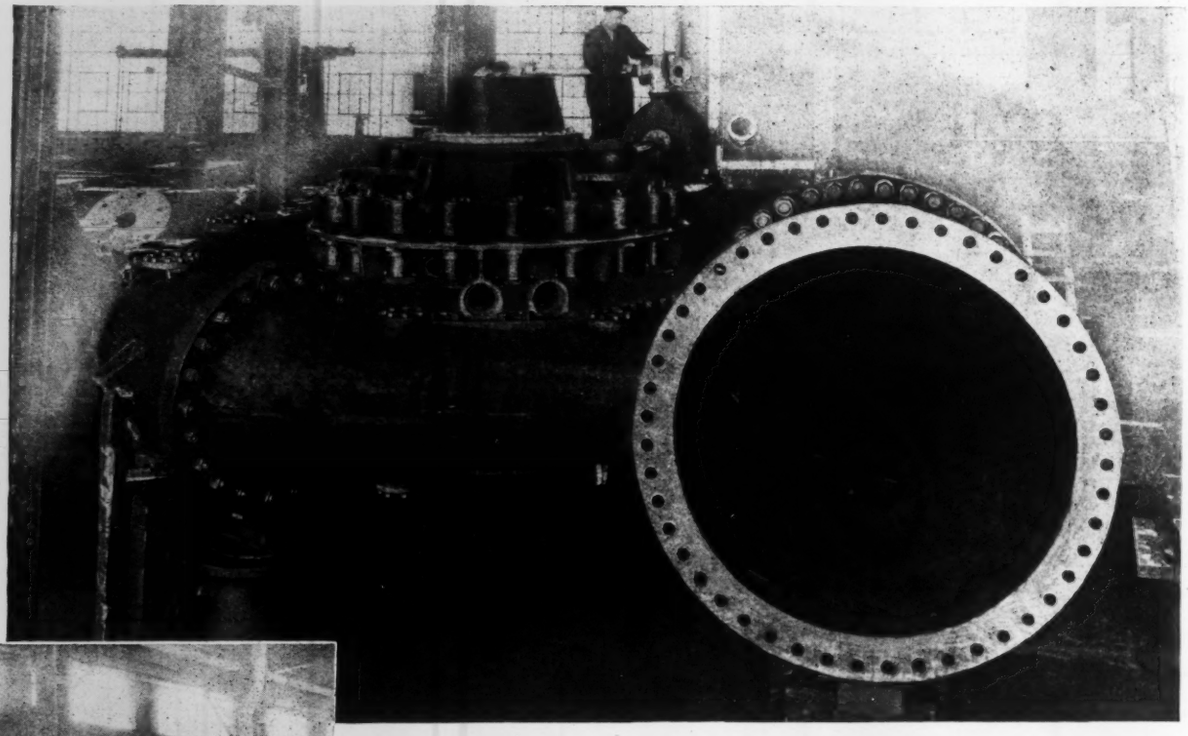

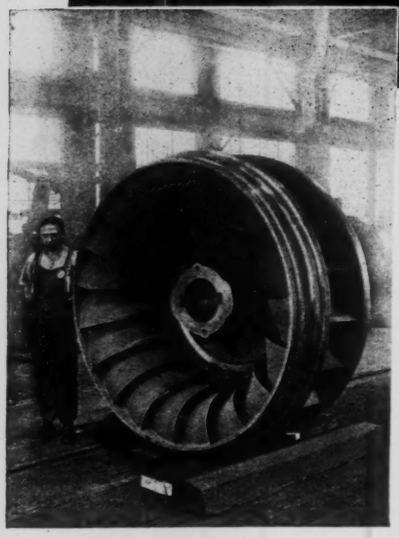

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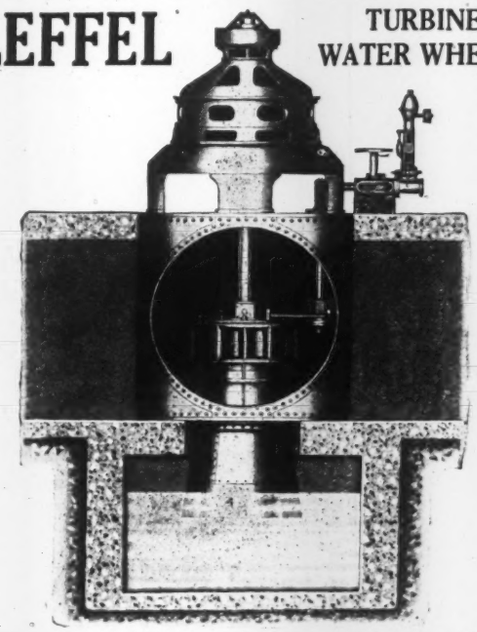

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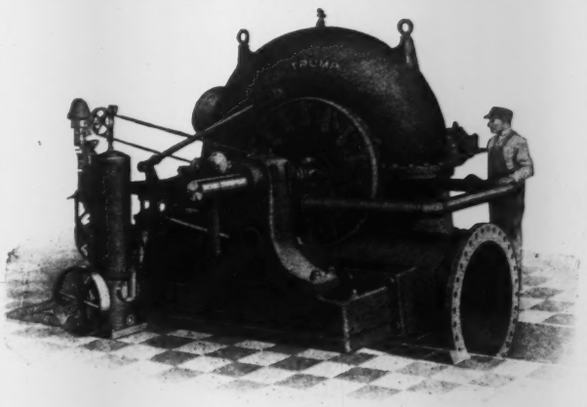

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Over 35 years' experience in the exclusive manufacture of water power machinery.

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A unique and valuable collection of information to be found nowhere else in the world and of incalculable value to engineers having to deal with problems of hydraulic design and construction

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ABB

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for normal or high pressures and superheats
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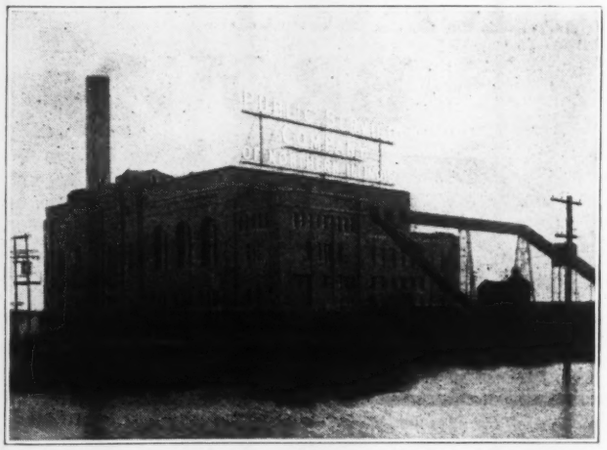

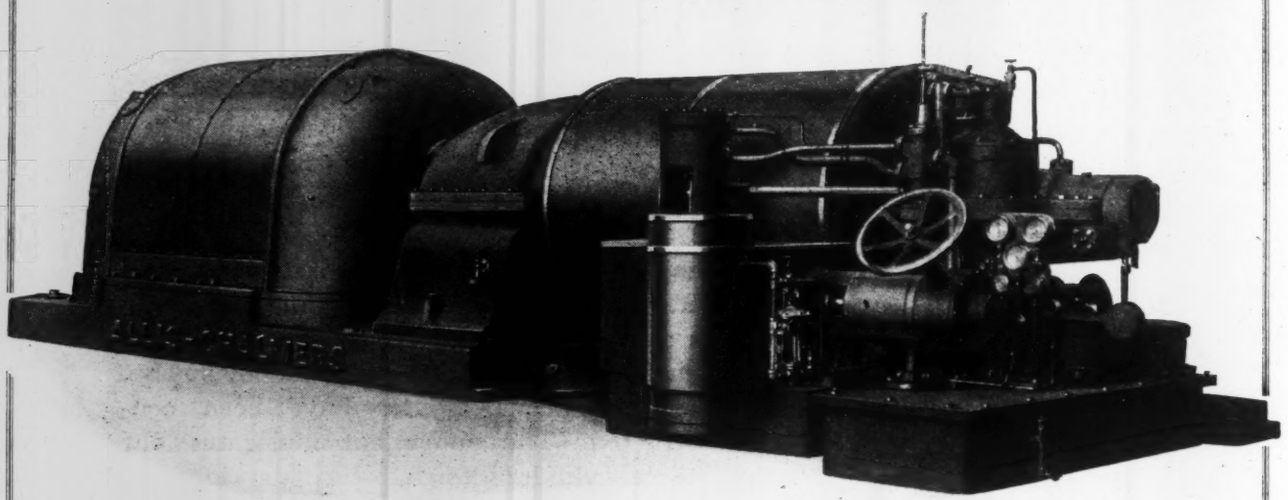

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The Ozark Smelting & Mining Co.—Negligible repair costs and maintained economy demonstrated by 7 years of continuous operation.

Operating records speak for themselves.

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STEAM TURBINE SPECIALISTS

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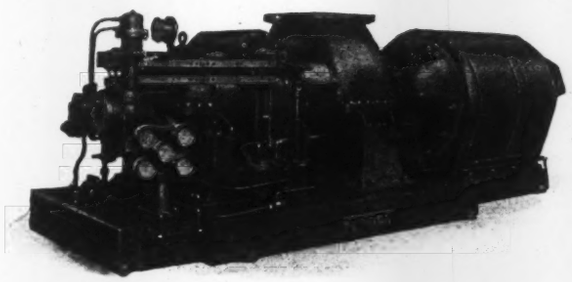

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There is only ONE right steam turbine application for a given installation.

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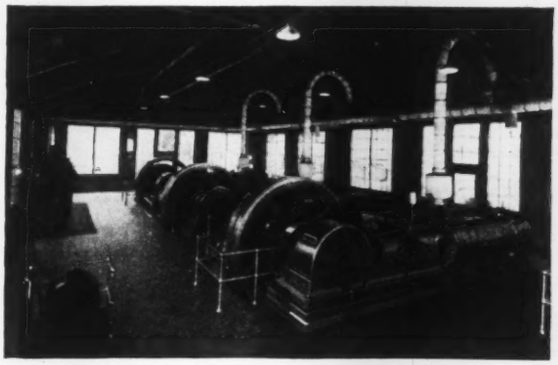

The highest-priced steam engine naturally should be the hardest to sell, but more "Universal Unaflow" engines, in spite of their high price, have been sold than any other make of American unaflow engine.

This fact alone should influence you to investigate the reasons why so many purchasers have bought these engines and why large corporations have adopted them as a standard.

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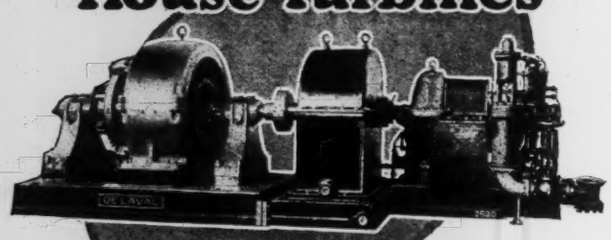

–for the New 14th St. Station, N. Y. Edison Co.

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654

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Flexible Couplings, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines and Special Centrifugal Machinery.

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ICE MACHINERY SUPERIOR SINCE 1882

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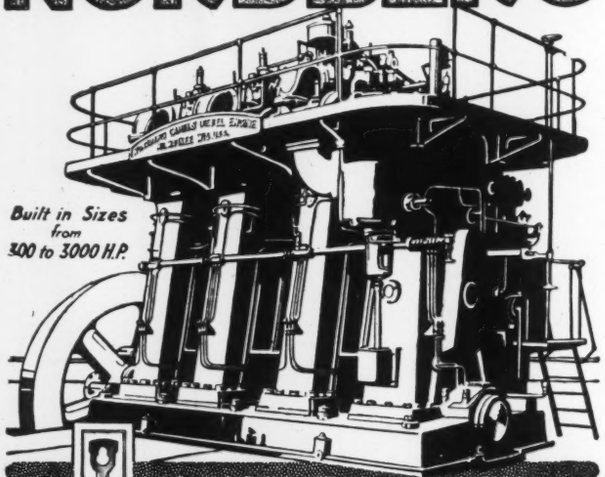

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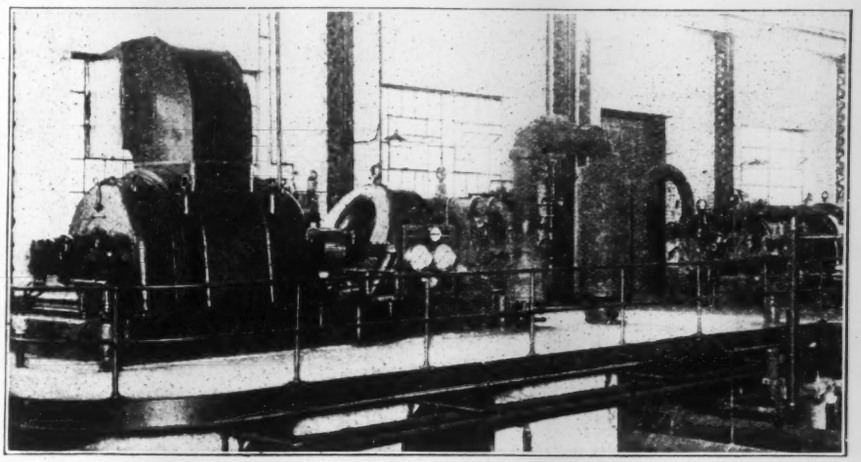

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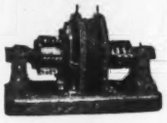
Motor Generators

Turbines


Rotary Converters

Synchronous Motors

The City of Springfield, Ill., operates the two Ridgway Turbo-Alternators illustrated above. The larger unit, in the foreground, is a 3000 k.w. machine which was installed after several years' satisfactory experience with the smaller unit, in the background, a 1500 kw. machine. Both sets are of Ridgway standard construction as described in Bulletin No. 31-F. Ask for it.

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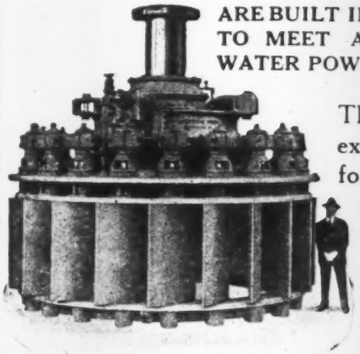

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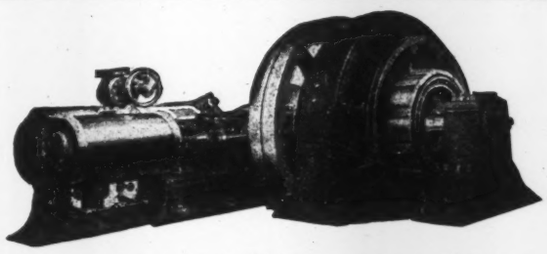

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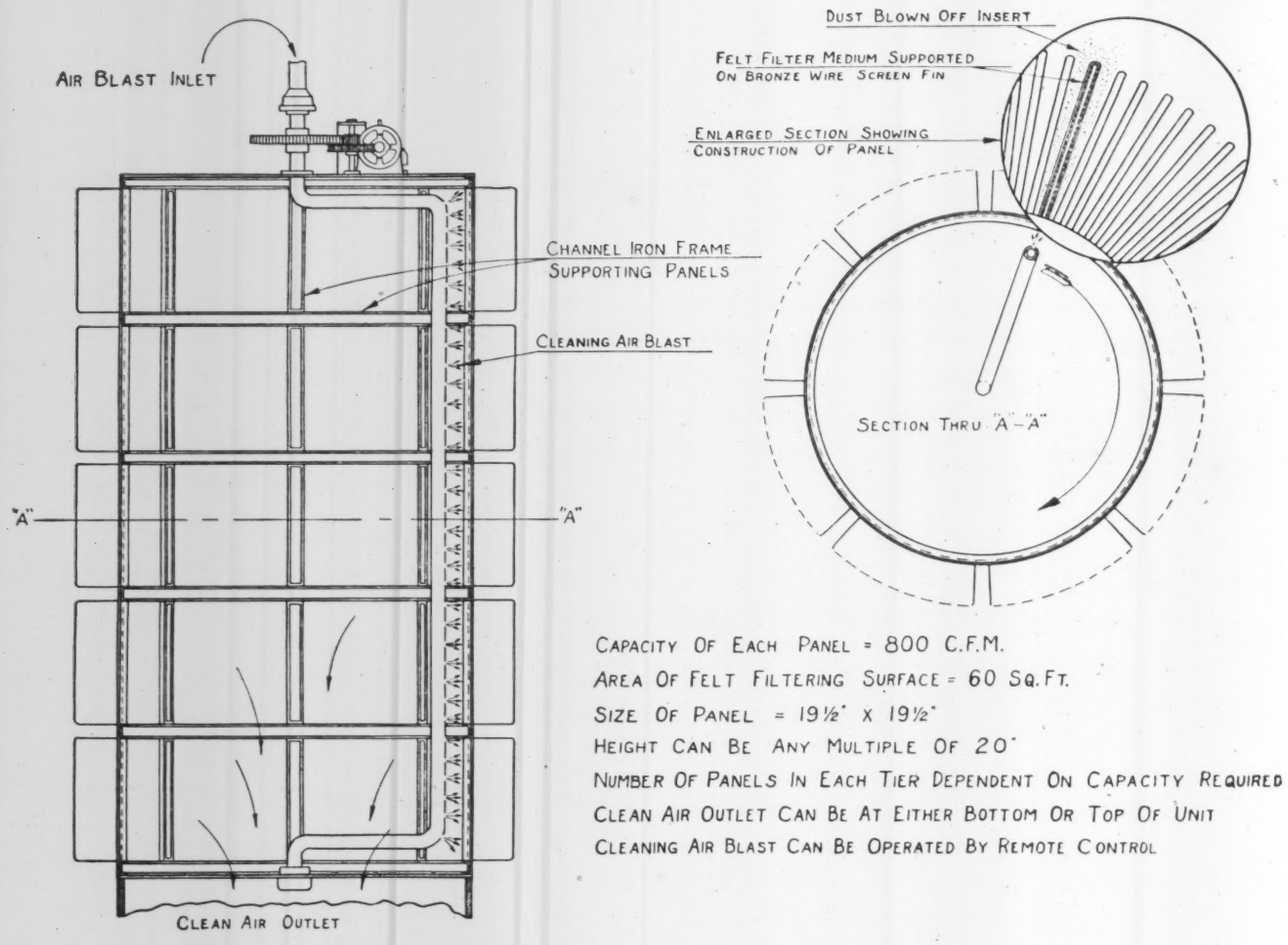

CAPACITY OF EACH PANEL = 800 C.F.M.
AREA OF FELT FILTERING SURFACE = 60 SQ. FT.
SIZE OF PANEL = 19½" X 19½"
HEIGHT CAN BE ANY MULTIPLE OF 20"
NUMBER OF PANELS IN EACH TIER DEPENDENT ON CAPACITY REQUIRED
CLEAN AIR OUTLET CAN BE AT EITHER BOTTOM OR TOP OF UNIT
CLEANING AIR BLAST CAN BE OPERATED BY REMOTE CONTROL

Panel Units

For ventilating and blower systems operating with a low suction the Protectomotor Panel Unit is particularly effective.

The filter panels are 19½ inches square and can either be mounted in a standard 20 x 20 frame or can be curved to fit a cylindrical channel iron frame as shown above.

The unit illustrated contains 40 panels and is capable of passing 32,000 CFM of air. The cylindrical form permits the mounting of filter capacity, sufficient to pass a large volume of air, in a relatively small space.

The felt can be cleaned by the device shown above consisting of a vertical pipe, perforated for the passage of a cleaning blast of compressed air; which is arranged to rotate within the frame of the unit at a speed slow enough to insure each fin individually receiving the full pressure of the cleaning blast.

The ease of maintaining Protectomotor Air Filters is in striking contrast to the laborious methods employed in cleaning less efficient types of air cleaners. No oil drains or cleaning tanks are necessary and the total absence of any need for moving the panels, once they are in position, not only contributes to the efficiency of this type of Protectomotor but it is also an important factor in the significant reduction of maintenance costs, which in combination with the high efficiency provided, places the Protectomotor Panel Unit in a unique position of preference.

Protectomotor is made in sizes from 5 cubic feet to 50,000 cubic feet capacity. Requires least attention. Cleaned while in operation. Superior to water filter because it introduces no moisture or humidity into the air. Send for catalog.

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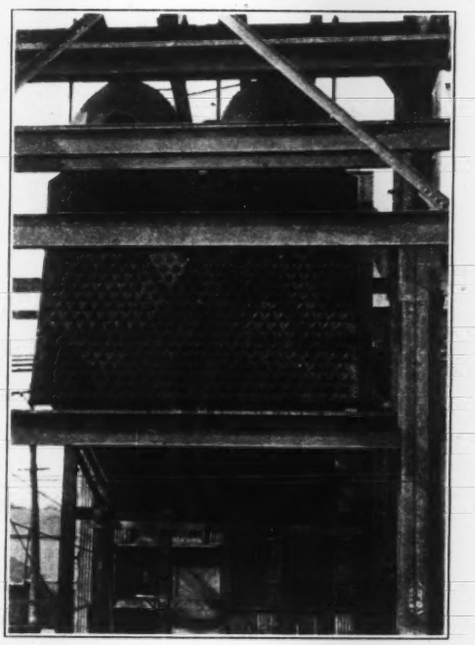

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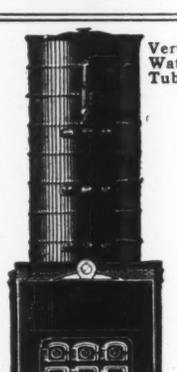

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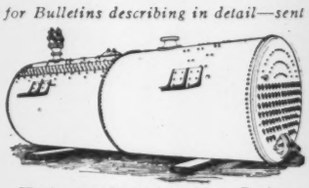

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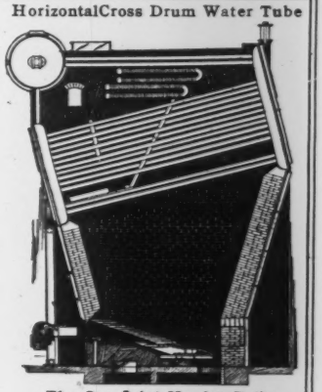
HorizontalCross Drum Water Tube



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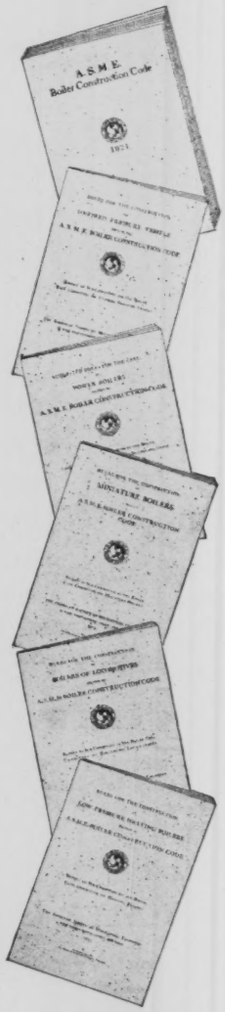

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Edition of 1924

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The price of a set of the Interpretations to the 1924 code including a binder, $3.00. Subscription to the Service for the current year $2.50.

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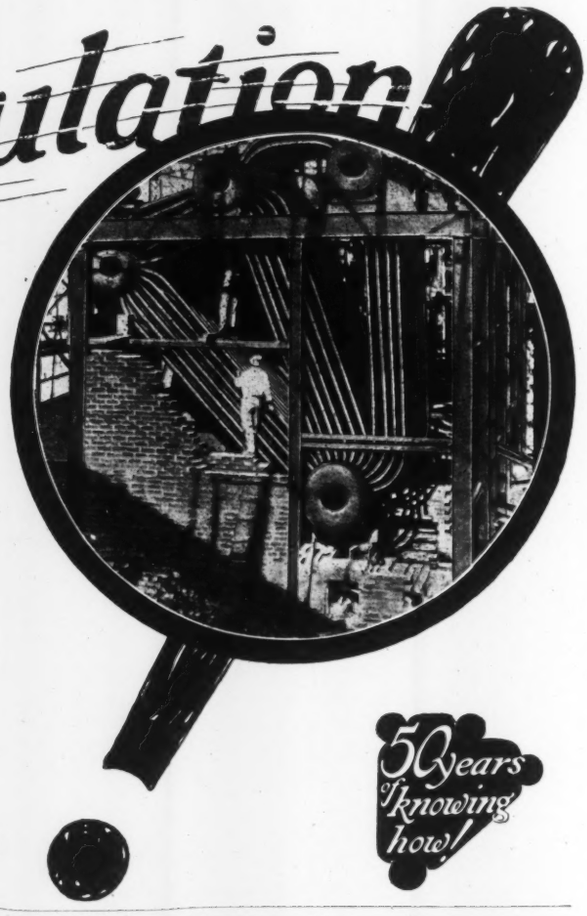

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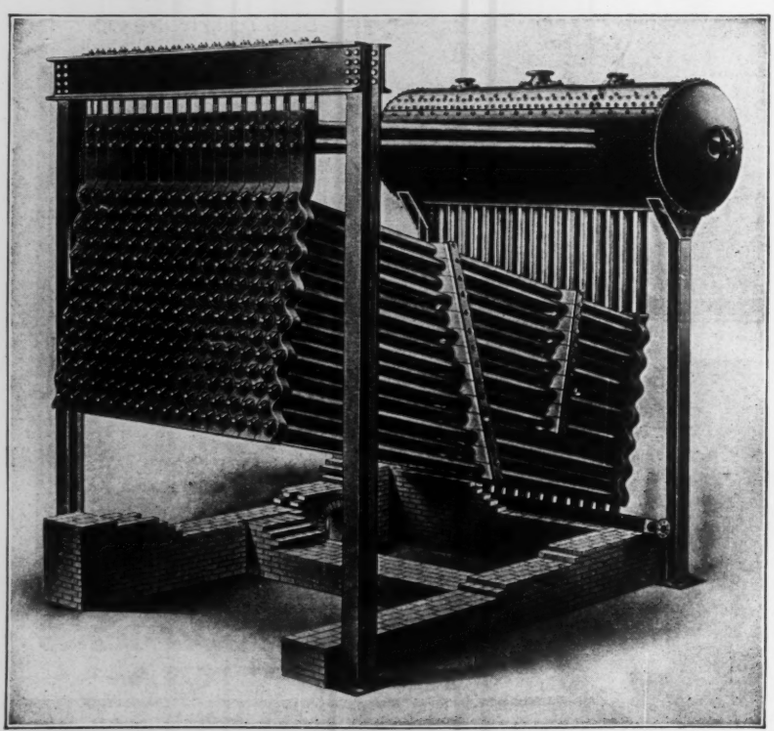

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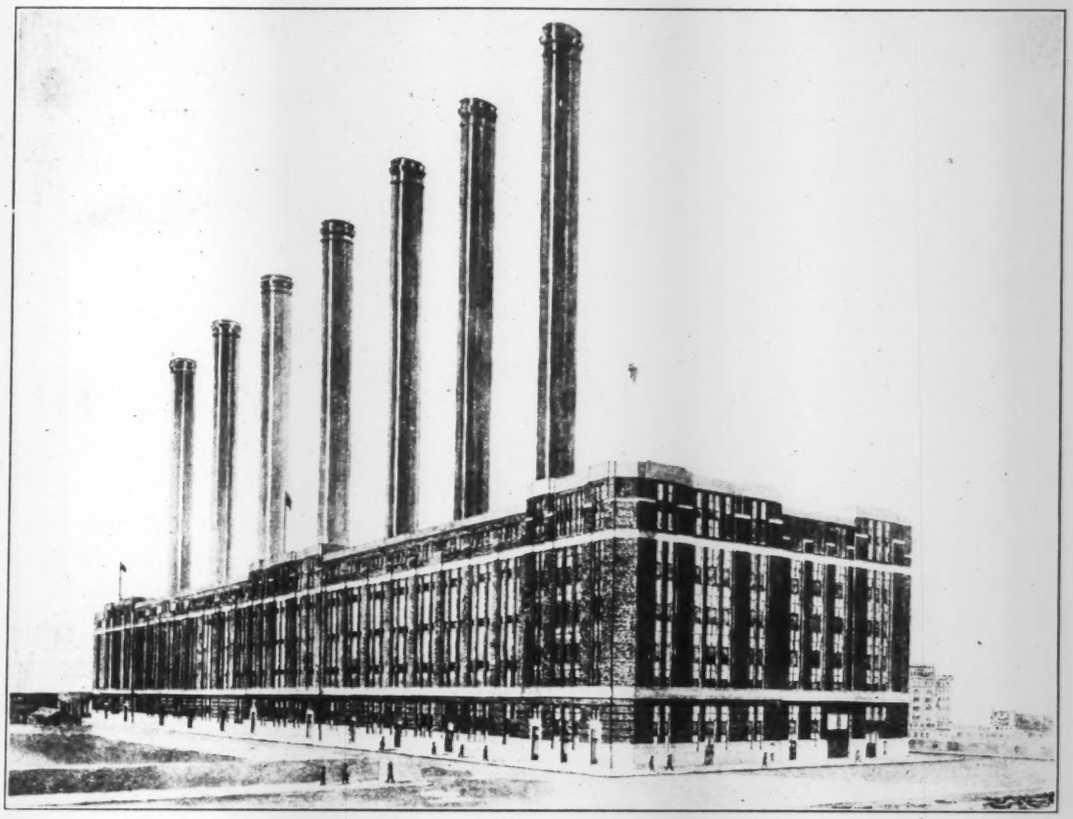

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One of the 24 Heine M-Type Boilers used in Crusader Pipe Line Service View shows Urbana, Arkansas — Station No. 1 of this pipe line.

Heine Boilers Built By Heine

Wherever the wheels of industry turn, there you will find Heine Boilers rendering conspicuous service. Take the petroleum industry, for example. Here, as elsewhere, Heine Boilers enjoy a reputation for reliability and efficiency, earned under most exacting conditions. Year after year, they generate power that transports millions of gallons of crude from wells to refineries, where Heine Boilers are also doing service in converting crude into finished products.

Among recent Heine activities in this field are the following:—

In a single refinery, Heine has installed about 8000 h. p. of MC-type boilers operating as waste heat boilers on hot gases from stills.

A large midwestern refinery has placed its third order for four 522 h. p. Long Drum HC-type boilers.

A Texas refinery has just completed the installation of three Heine V-type boilers to be fired with petroleum coke.

Heine Boilers are made in the following types: "Heine-Built" Long-drum Boilers, either horizontally or cross-baffled; "Heine-Built" Cross-drum Boilers, either horizontally or cross-baffled; "Heine-Built" Bent-tube Boilers, designated as "V Type"; Special Construction, including Water-cooled Arch Supports, Water-cooled Walls, etc.

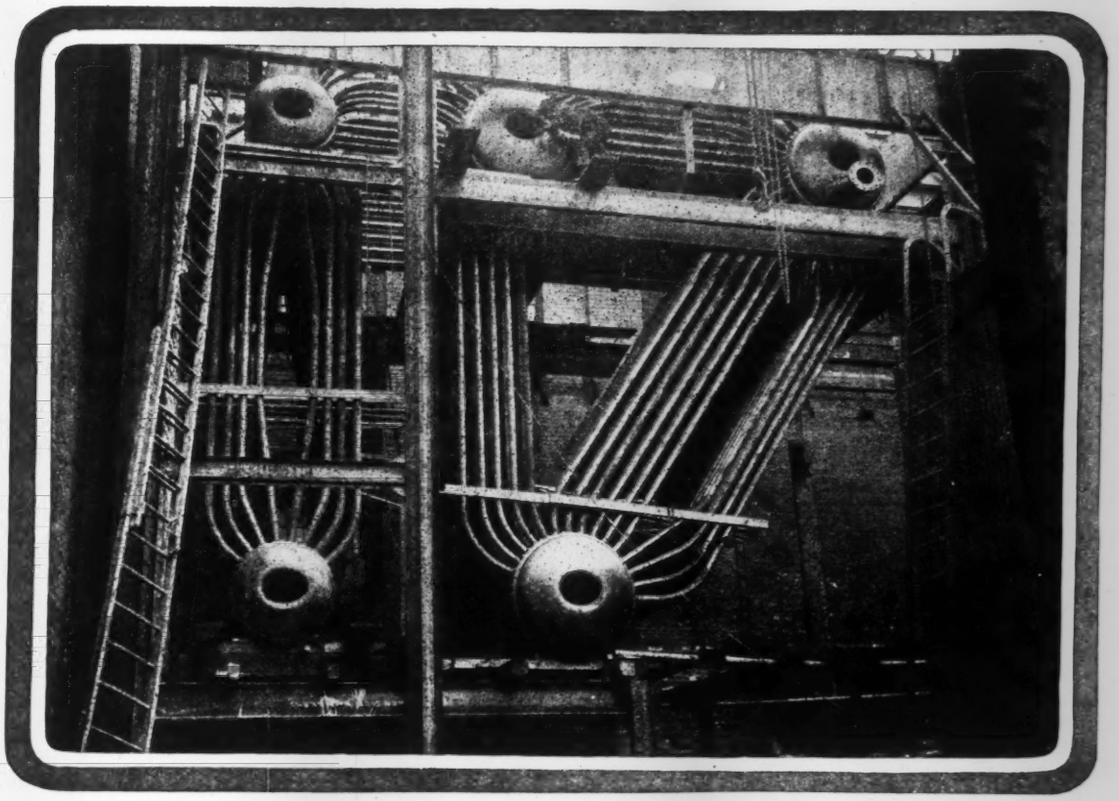
It is the ability to provide the right boilers for the right service, plus a diversified experience extending over 44 years that enables Heine Engineers to design boilers giving consistently superior performance.

* * *

See our exhibit in the 5th National Exposition of Power & Mechanical Engineering, Grand Central Palace, New York City, December 6 to 11, 1926. Booths No. 694 & 655.

Heine Boiler Company
SAINT LOUIS, U.S.A.

Heine Boilers



Get the facts on this new Three-Drum Boiler

Pictured above is a typical installation of one of the new Erie City Three-Drum Boilers.

Free from Priming

The perfection of a new method of circulation in these boilers has made it possible to avoid all danger of priming.

Dry Steam

At the same time this perfected circulation has presented a method of giving dry steam—not just "commercial" dry steam but a steam that is further dried after it has given up the larger particles of water.

Easy Tube Removal

By its special construction any and all tubes in this Three-Drum Boiler can be reached by a workman for removal.

Continuous Service

Erie City Boilers are built for a long period of continuous service. Many unnecessary parts that cause trouble have been eliminated; the boiler proper is independent of the furnace; all parts are made by craftsmen working on carefully inspected materials.

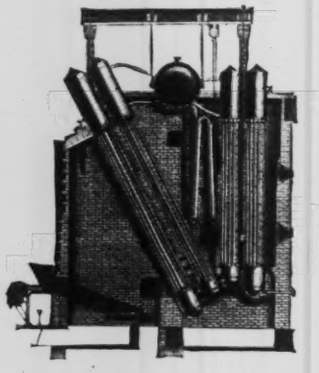
Write for complete new catalog

We have listed above just a few of the high points of this new Three-Drum Boiler. A copy of our new catalog giving details will be sent on request.

ERIE CITY IRON WORKS

ERIE, PA.,

MODERN STEAM POWER PLANTS



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WATER-TUBE BOILERS

"For over fifty years, we have been manufacturing steam boilers. We are the oldest and largest manufacturers of steam boilers in the New England States and have established a reputation of unexcelled workmanship and material; always striving to improve our product in every possible way, and having a plant equipped throughout with most modern up-to-date machinery."

Manufacturers also of

The Bigelow Horizontal Return Tubular Boiler
The Bigelow-Manning Boiler
The Bigelow Two-Pass Boiler

THE BIGELOW COMPANY
20 Lloyd Street, New Haven, Conn.

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THE BABCOCK & WILCOX COMPANY
85 LIBERTY STREET, NEW YORK

Builders since 1868 of Water Tube Boilers of continuing reliability

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Bayonne, N. J.
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Makers of Steam Superheaters since 1898 and of Chain Grate Stokers since 1893

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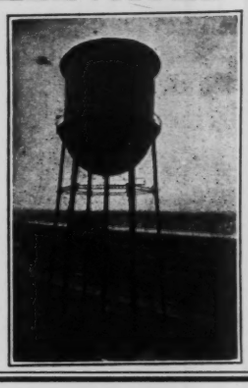
ELEVATED STEEL TANKS



Our elevated tanks are correct in design; and their simplicity of structure contributes to the low cost of maintenance. Sprinkler tanks and equipment incorporate the recommendations of all insurance authorities; and special designs will be furnished to meet individual requirements.

Our facilities provide also for the design and construction of all forms of steel plate work, including stacks, acid tanks, pressure vessels, structural frames and towers.

See also page 49 in the 1926-27 volume of A.S.M.E. Condensed Catalogues

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"PENNSYLVANIA" *STEELBUILT* CRUSHERS

POWER PLANT EFFICIENCY

Is notably increased by the use of properly prepared coal. "PENNSYLVANIA" *STEELBUILT* Bradford Breakers and Single Roll Crushers insure an uninterrupted supply of stoker coal, of the desired size.

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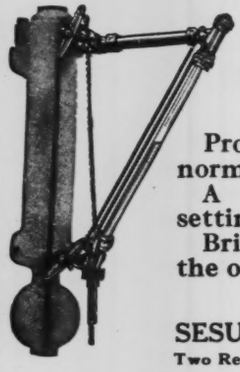

SESURE
Inclined Water Gauge

Patented

Protects boilers against abnormal water level.

A vital necessity on high settings.

Brings the water level out in the open.

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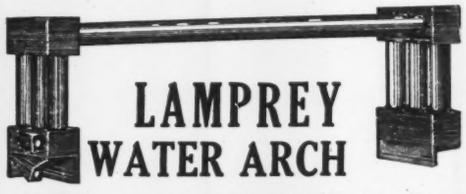

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FREE 60 DAY TRIAL

A Water Cooled Fire Door Protector

Eliminates all repairs to front masonry and boiler fronts. Saves fuel and pays for itself the first year. Guaranteed for a term of years. Can be installed in one day.

Send for booklet explaining more fully the economy of this device.

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25 years on the job ~~ and "Good as Ever"

Edge Moor Boilers at United States Glue Co., Carrollville, Wis. Four of these boilers have been in continuous service for twenty-five years, and are still in excellent condition.

IN the plant of the United States Glue Co., at Carrollville, Wis., there are today four Edge Moor Boilers that have completed a quarter-century of continuous service.

In the same plant are eight other Edge Moor Boilers installed between 1904 and 1919. Yet it would take a keen eye to detect the difference in age, for all the boilers are in uniformly excellent condition. The 25-year-old "veterans" carry their full share of the load with the newer boilers.

The company's opinion of the boilers and their performance is best reflected in a recent remark of the Plant Superintendent:

"When we need more boilers, we will buy nothing but Edge Moors."

Obviously, careful operation is essential in the establishing of unusual service records. Yet to an exceptional degree, the qualities of service and long life are built into all Edge Moor Boilers. They are a life-time investment.

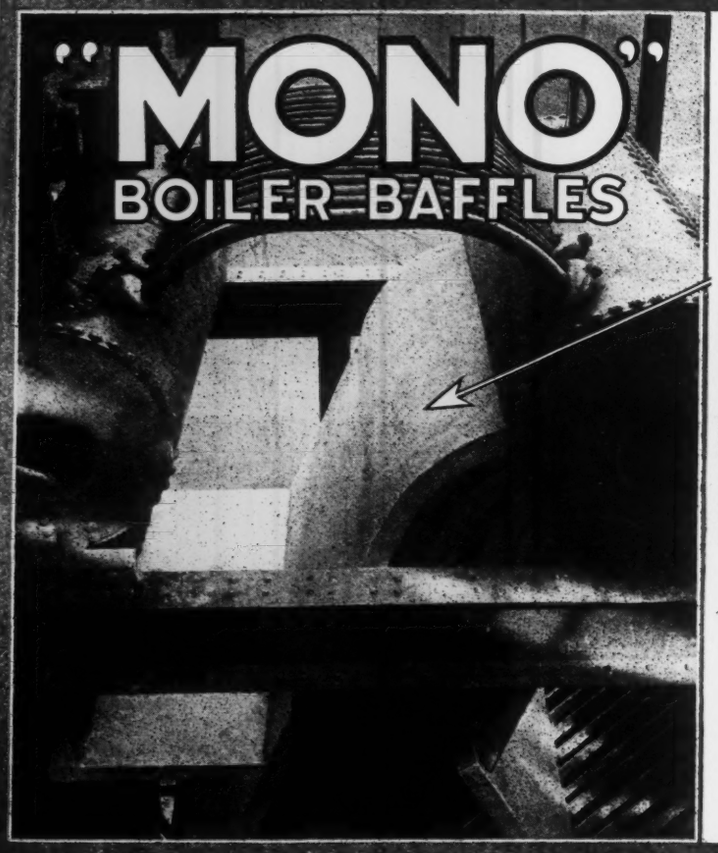
Details are in the Edge Moor catalog — sent free at your request

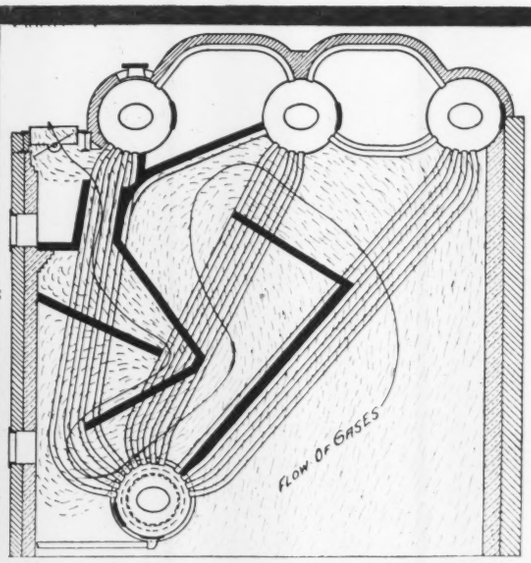
EDGE MOOR IRON COMPANY
Established 1868
EDGE MOOR, DELAWARE

New York Chicago St. Paul Boston Pittsburgh Charlotte Los Angeles

EDGE MOOR Water Tube BOILERS

FOR INCREASED FUEL ECONOMY



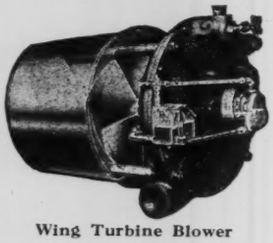


The illustration above shows how "MONO" BAFFLES force the gas to travel across the tubes in a bent tube boiler, thus increasing the heat transference instead of allowing the gases to short circuit at high velocity parallel with the tubes by the use of a vertical Baffle such as is usually installed in a bent tube boiler

Note how closely "MONO" BAFFLING follows the curve of the tubes: and how tightly it is jointed against the drum. "MONO" BAFFLING will retain its original form and tightness.

Our engineering department is at your service to help solve your BAFFLE problems.

KING REFRACTORIES CO., Inc.
1715 Niagara St. Buffalo, N. Y.


Wing Turbine Blower

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Wing Power Show
Booth 61 **EXHIBIT** Booth 61

Wing Unit Heater

Wing-Scruplex Exhauster

Wing Power Show Exhibit: forced draft equipment, both turbine and motor driven; heating and ventilating equipment, Wing Featherweight Unit Heater, Wing-Scruplex Exhauster and Fans.

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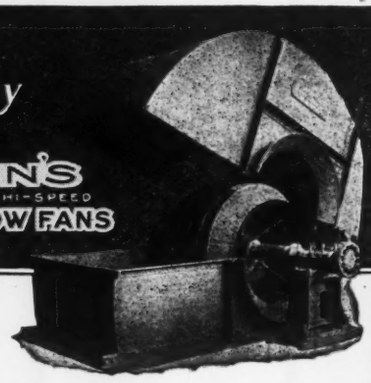
Save Auxiliary Power

GREEN'S
HI-EFFICIENCY HI-SPEED
RADIAL FLOW FANS



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GREEN'S
RADIAL FLOW
AND
STEEL PLATE FANS
MEET MODERN BOILER ROOM REQUIREMENTS

BULLETIN No. 127 - - STEEL PLATE
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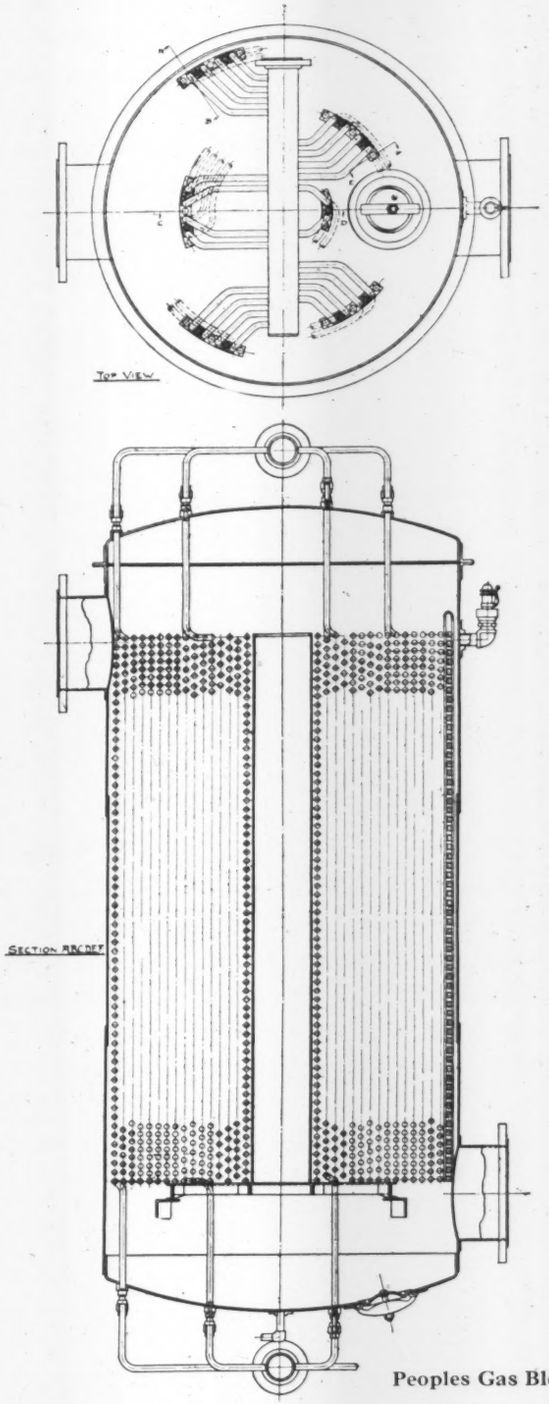
THE GREEN FUEL ECONOMIZER CO.
BEACON, N.Y.

Look to RE-SUPERHEAT for still better efficiency



Elesco Steam Reheater. Reheats Steam between Stages of a Turbine with Live Steam as Heating Medium.

DRY steam between all stages of the turbine makes for better operating efficiency—as well as better turbine blade life.

To insure dry steam—superheat and *reheat it.*

Reheating helps operations and saves investment by giving the thermal advantages inherent in a greater temperature head during the working cycle of the steam in the turbine.

On existing installations with modern turbines and old boilers...new high pressure boilers and high pressure turbines may be installed with reheaters between new and old turbines.

On new installations *reheat* the steam between stages with a Reheater.

The subject of reheating is one which merits the consideration of executives since careful laboratory experiments indicate that for every one per cent of moisture present in steam passing through a turbine stage, the efficiency of this stage is reduced by 1.15 per cent and more, due to the increased friction.

An exhaustive study on this subject will be mailed to those interested on request to

THE SUPERHEATER COMPANY
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Peoples Gas Bldg., CHICAGO ELESCO **Union Trust Bldg., PITTSBURGH**

Represented in

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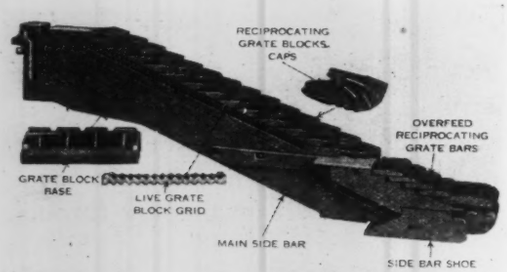
To Accomplish These Desirable Results Use Reciprocating Retort Sides

Keep the fuel bed moving progressively toward the dump mechanically without depending upon the uncertain effect of gravity.

Keep the fuel bed always active, porous and uniform to assure lowest excess air.

Prevent the formation of large clinkers thereby preventing grate burnouts from the reverberatory action of flames under large fixed clinkers.



One unit of the reciprocating retort sides, showing the air supplying grates and the special underlying grid construction. The movement of these units keeps the fuel bed open, porous, and free from clinkers.

The reciprocating retort grates, an exclusive feature of all Riley Stokers, accomplish these desirable results is proven by every day performance in the thousands of plants using Riley Stokers. Every day practice proves the soundness of this construction. The absolute effectiveness of reciprocating retort sides with moving grates, can be readily observed by moving pictures of the Riley Stoker fuel bed. These pictures show how effectively moving grates cut and slice the fuel bed along the shearing line over each retort, maintaining at all times an even, porous, uniform fuel bed.

Moving Grates and other exclusive Riley Features are described in Catalog 82. Ask for it.

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RILEY JONES MURPHY

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"RILEY" Underfeed Stokers
"JONES" Underfeed Stokers
"HARRINGTON" Traveling Grate Stokers
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The SIMPLEX UNIT SYSTEM
OF BURNING PULVERIZED COAL
UNIT PULVERIZER — PIPING — FE FURNACE — FE BURNERS

8 Simplex Units of an installation of 20 Units at the Ashley St. Station, Union Electric Light & Power Co., St. Louis, Mo.

A few of our installations are shown here

Photographs of others may be seen at our booth as well as an actual Simplex Unit Pulverizer and the F E Burners. Our engineers will be there to discuss your boiler room problems with you — no obligation — and demonstrate the merits of the Simplex Unit System of burning pulverized coal.

Will also be exhibited at the Chicago Power Show. If you cannot visit our exhibits write to us or our nearest branch for information.

See our Exhibit in Booth No. 41 - at New York Power Show

At Sherman Creek Station, United Electric Light & Power Co., New York, N. Y.

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A battery of Simplex Units, Spang, Chalfant Co., Pittsburgh, Pa.

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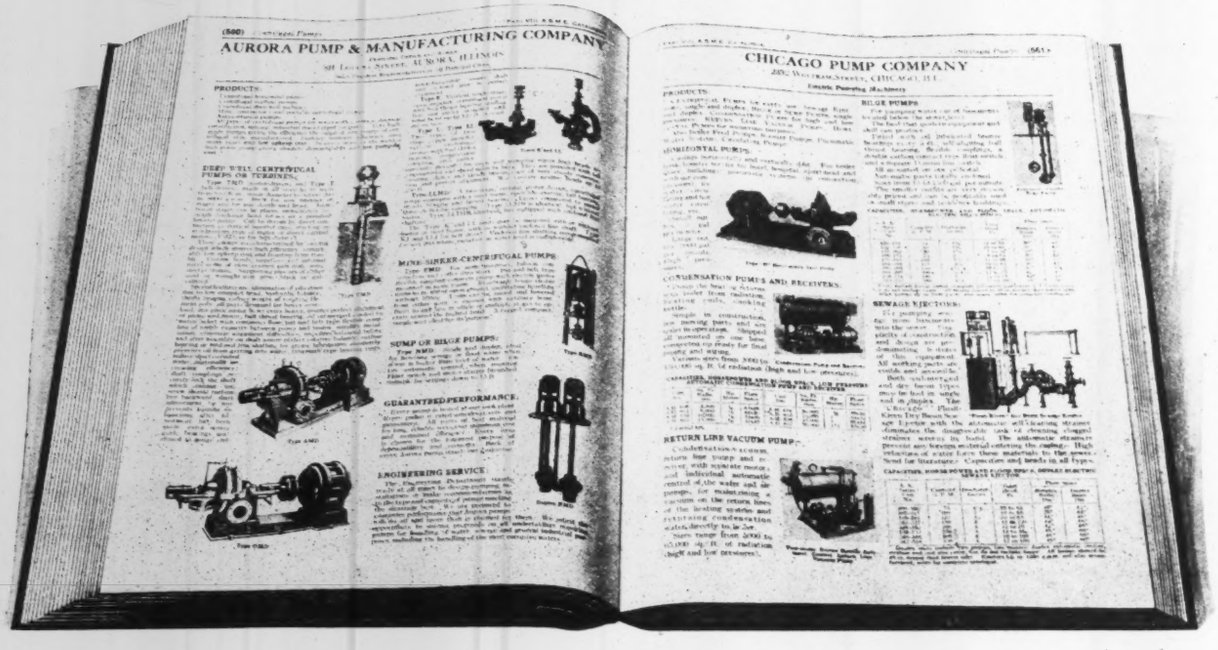

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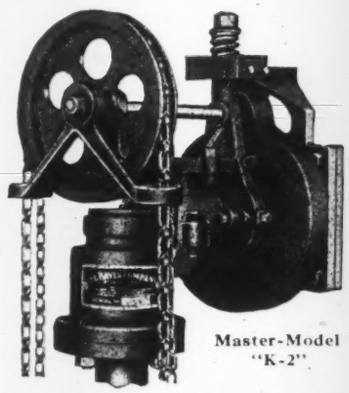

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Balanced-Valve-in-Head Soot-Blower
—for All Types of Water-Tube Boilers

—embodies the important BAYER Principle—it properly directs a full blowing-force from start to finish of cleaning arc without loss of steam caused by the gradual opening and closing of the valve.

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The BAYER Special High-Temperature Blower-Element—Monel Metal Sheathed and Air-Cooled—is built for long and efficient service—"Stands up in 'hot-spots'."

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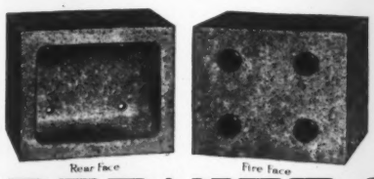

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Super Block
9"x7⅝"x7" deep.
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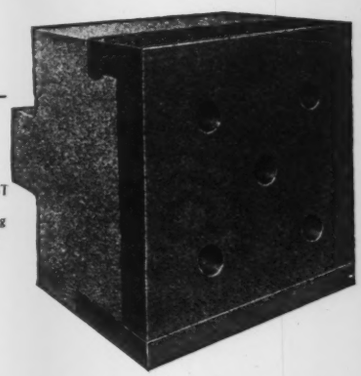

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There is a DRAKE BLOCK for every furnace use
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No Scale No Pitting No Foam

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Please send .....copies of "Standard Specifications for Clean and Dry Steam."

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TRACYFIER
Assures the
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Delivery of
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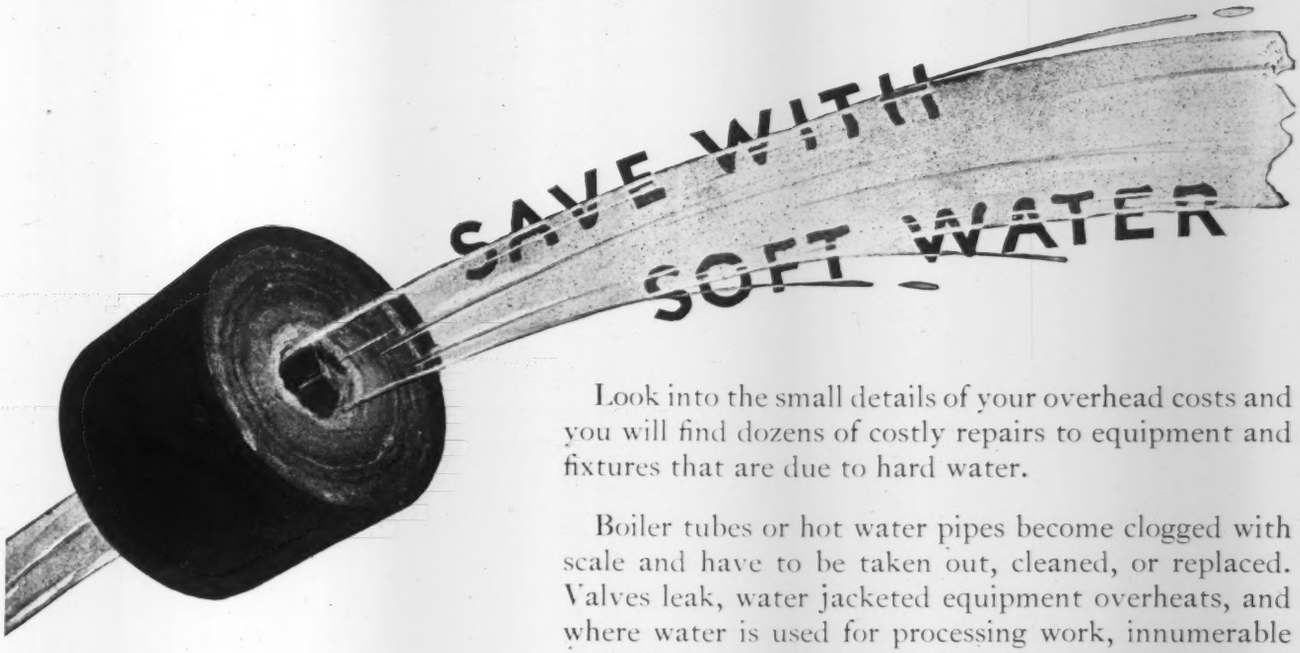
Steam



Look into the small details of your overhead costs and you will find dozens of costly repairs to equipment and fixtures that are due to hard water.

Boiler tubes or hot water pipes become clogged with scale and have to be taken out, cleaned, or replaced. Valves leak, water jacketed equipment overheats, and where water is used for processing work, innumerable manufacturing difficulties are continually arising.

These troubles are part of your manufacturing problems, their cost is absorbed in general factory overhead and you submit to them because they have always existed—but you do not have to.

Soft water will reduce these items amazingly. It will eliminate costly boiler cleaning completely, it will reduce repairs and troubles throughout your plant in a dozen ways, and it will pay for itself very definitely and quickly.

Permutit water softening apparatus is simple, it is easy to install and inexpensive to maintain. It can be operated by unskilled labor. More than ten thousand plants in the United States alone are Permutit equipped.

Let us send you literature showing how Soft Water will effect Savings in your business.

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The Consolidated Gas & Electric Co. of Baltimore substituted soft water for hard in 1922. A report covering one period of operation shows a saving of 2400 hours of boiler cleaning labor, 4 tube replacements against 28 and a gain of ½ lb. of water evaporated per pound of coal.

Garfield, N. J.
The Hammersley Manufacturing Co., Garfield, N. J., effected a net annual saving of $12,920.80 in boiler repair materials and labor alone by substituting soft water for hard.

Permutit
(Per-mute-it)
water softeners
Take all the hardness out of water

The Permutit Company
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Please send me your free booklet, "Reducing Fuel and Boiler Plant Operating Costs."

Name.....*Position*.....

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One order for Wisconsin Public Service Co., Green Bay, Wis. High and Low Pressure Heaters, Evaporators, and Evaporator Condensers.

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IN THE design of Croll-Reynolds Apparatus, modern thermodynamic theory and actual test data is coordinated with the practical knowledge and common sense acquired during sixteen years of experience. Every inquiry receives careful consideration and any possible modification of the original design or specifications which might lead to a saving in first cost, or to more efficient operation, is brought to the buyer's attention.

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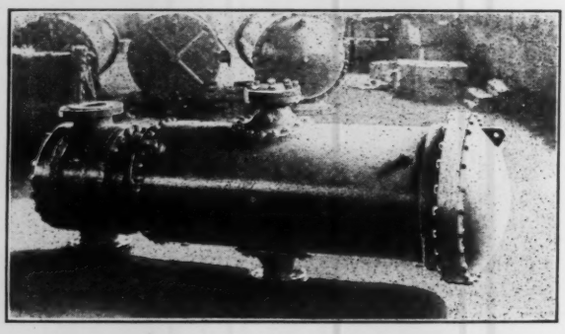
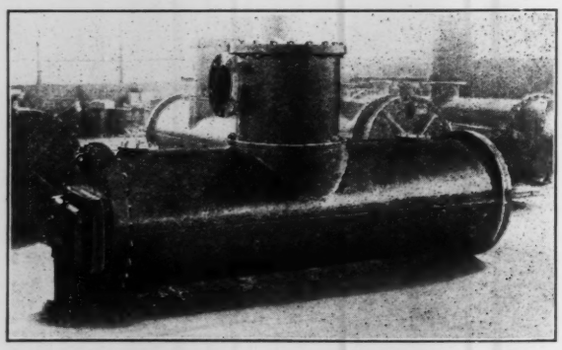
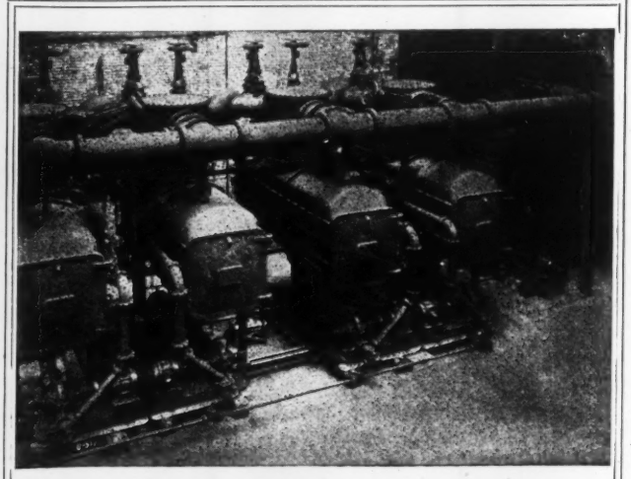


High Pressure Heater—500 lbs. Working Pressure, 750 lbs. Test Pressure. A.S.M.E. Code shell, 325 lb. Test Pressure.



Low Pressure Submerged Type Evaporator—Large Disengaging Area, Wide Tube Spacing, effective entrainment separator. *Tube Bundle rests on wheel supports for easy removal.*



Evaporated Feed Water

For High-Pressure Boilers (650 lbs.)

THE boilers at the new 100,000 kv-a. station of the Exeter Power Co., at Stanton, Pa. (Sargent & Lundy, Engineers), are to operate at 650 lbs. pressure. Experience with Wheeler Evaporators at Philo, Twin Branch and other high-pressure stations has demonstrated the advantages of distilled feed water for high-pressure boilers.

The photograph shows the Wheeler Quadruple Effect Film Type Evaporator to be installed at Stanton. When supplied with steam at 22 lbs. Abs. pressure, this unit will produce 40,000 lbs. distilled water per hour.

The Condensers for the 50,000-kv-a. Turbines at Stanton are special Wheeler Condensers with the tubes expanded in both tube sheets so that circulating water leakage cannot contaminate the condensate, completing the system of feed water protection. If the circulating water is polluted, condenser leakage will often introduce more solids into the boiler feed water than the use of raw water as make-up.

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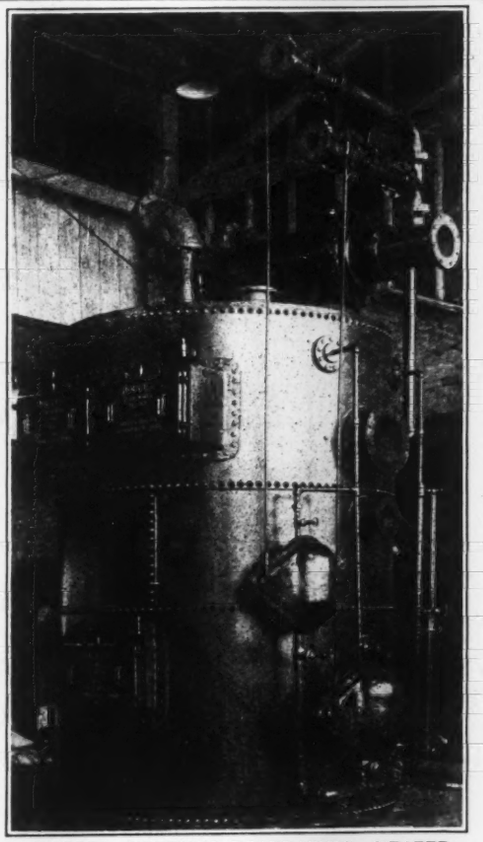

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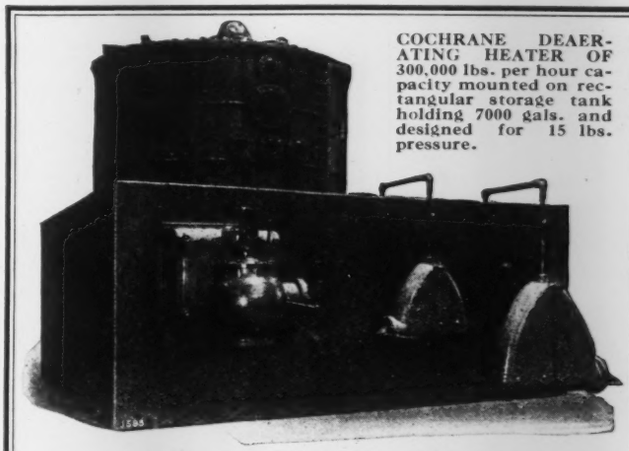

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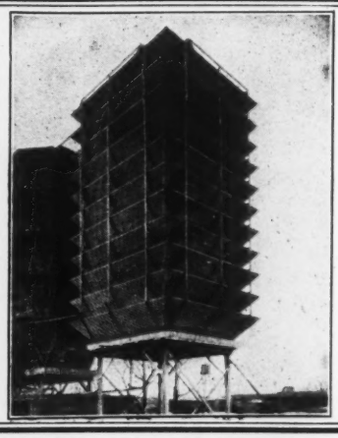

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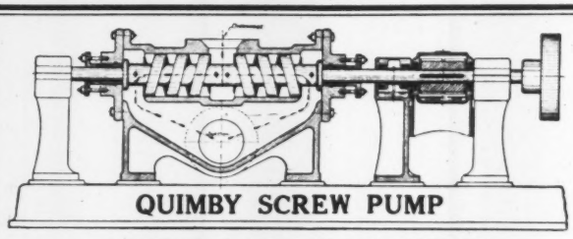

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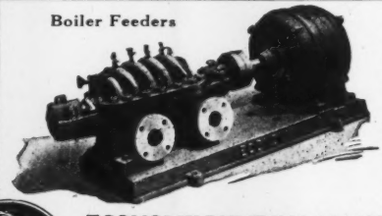

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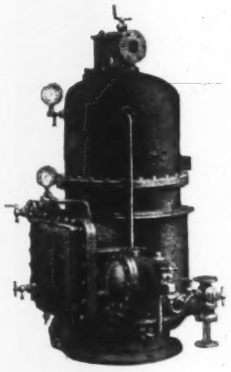
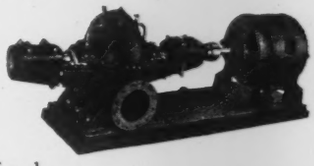
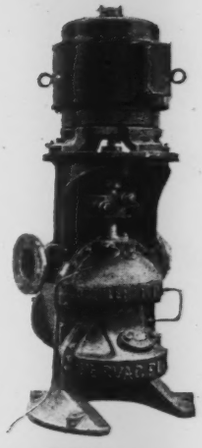
Some typical units *of* Bethlehem Power Plant Equipment

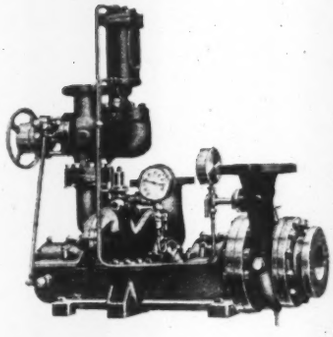


THE varied assortment of Power Plant Equipment manufactured by Bethlehem Steel Company is such that it includes units for auxiliary service throughout the whole heat cycle.



The illustrations herewith show only a few typical units representative of the complete line which we make. Whichever unit is chosen and whatever its application it has the capacity that enables it to contribute substantially and permanently to the overall economy of the plant.





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Motor- and Turbine-driven single-stage centrifugal Boiler Feed Pumps and General Service Pumps.

Motor-driven reciprocating General Service Pumps.

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Submerged-tube Evaporators.

Steam-driven reciprocating Fuel Oil, Lubricating Oil and Boiler Feed Pumps.

Motor- and Turbine-driven single-stage centrifugal Extraction or Condensate Pumps.

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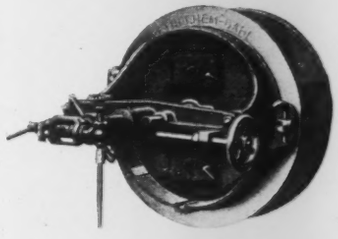
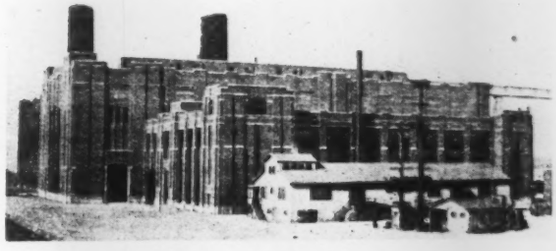
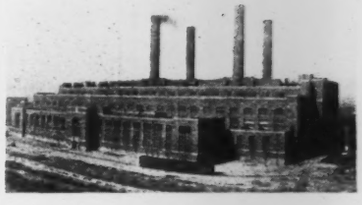


Typical Plants and Buildings in which Bethlehem Power Plant Equipment is Installed





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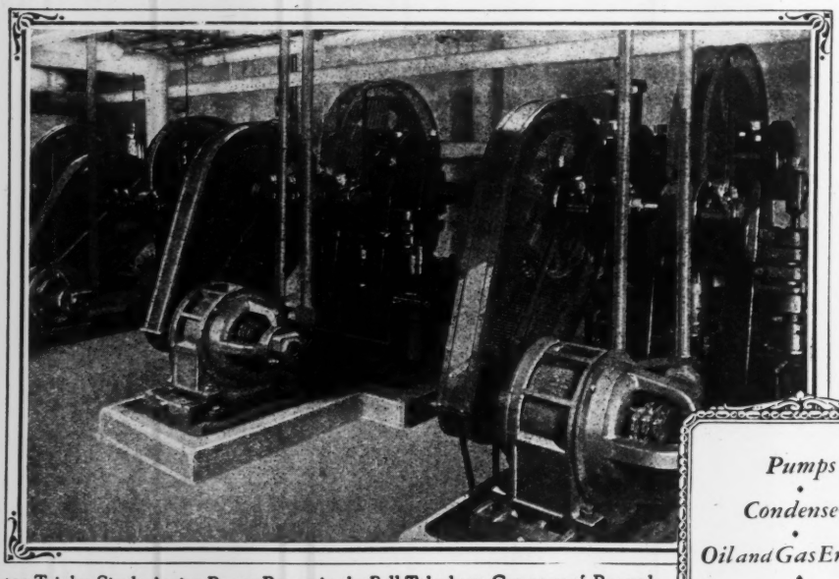

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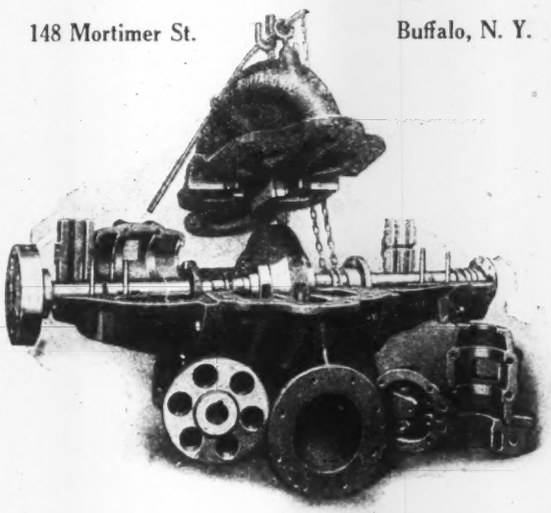

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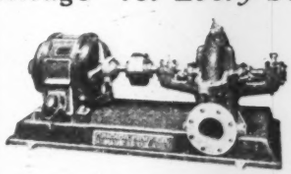

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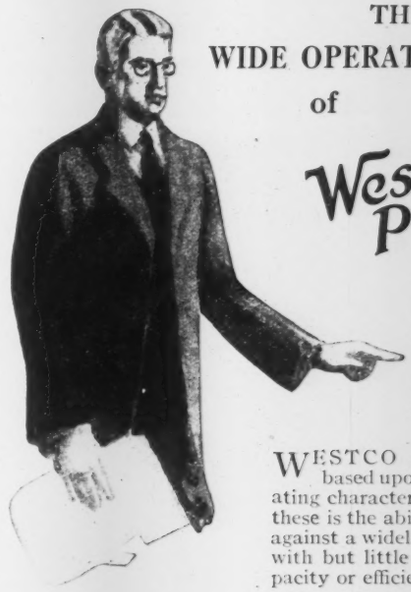

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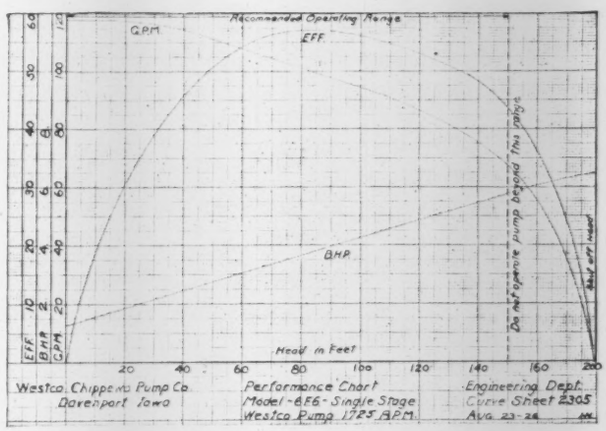
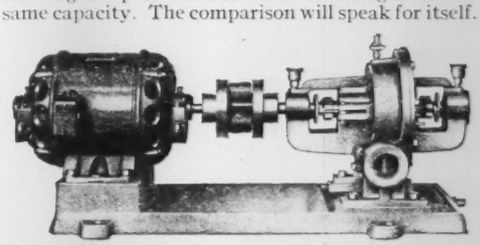


Place this Westco Pump curve along side a chart showing the performance of a centrifugal of the same capacity. The comparison will speak for itself.



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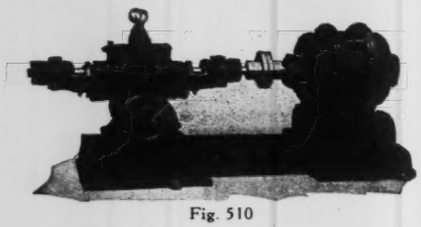

Fig. 510

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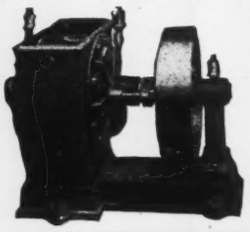

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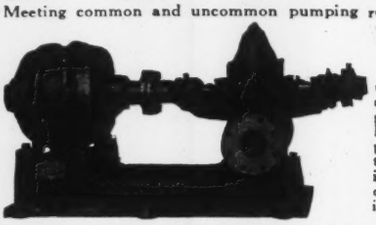

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November, 1926 MECHANICAL ENGINEERING Vol. 48, No. 10
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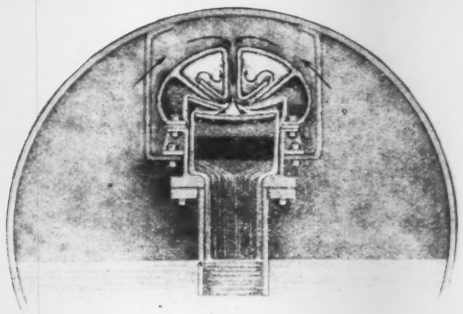

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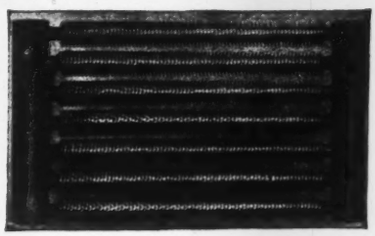

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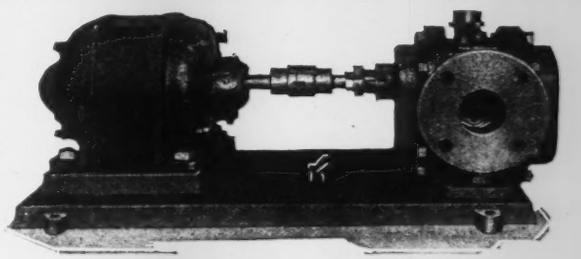

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Equipped with ball bearings.

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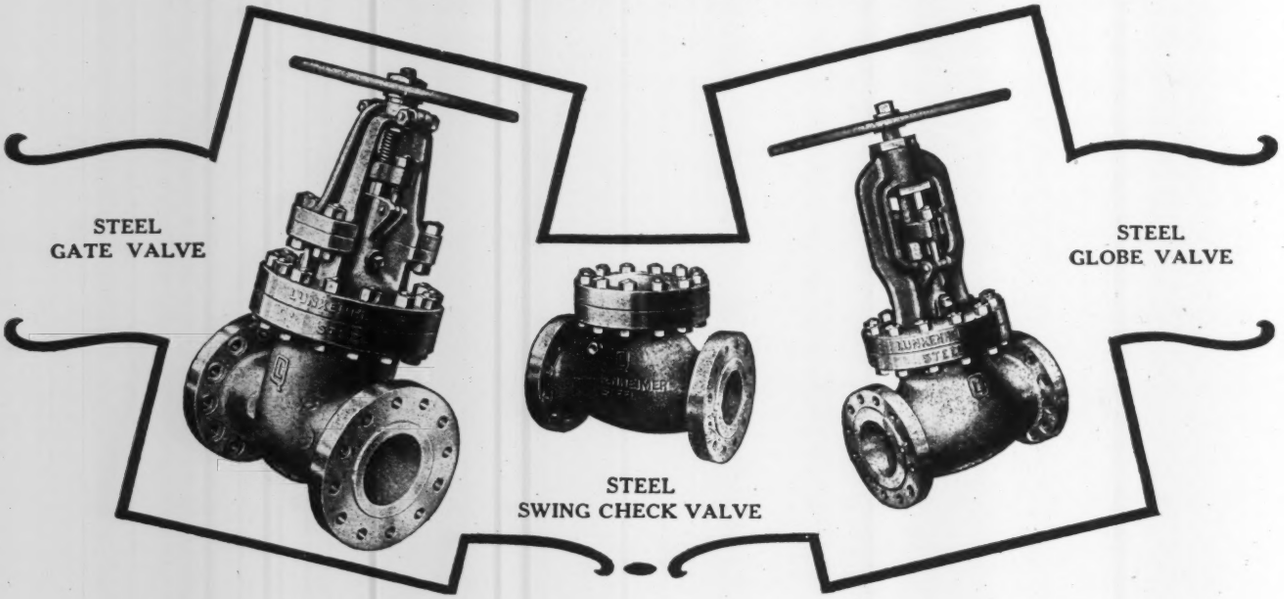
See our Flow Indicator ad on page 58

SCHUTTE & KOERTING CO. 1166 Thompson St. Philadelphia, Pa.
1876—Building jets 50 years—1926

See Our Data in 1926-27 A.S.M.E. Condensed Catalogues of Mechanical Equipment

See Our Exhibit Booth No. 63 "POWER SHOW"



LUNKENHEIMER STEEL VALVES

PROCURABLE FOR

250, 400, 600 AND 900 LB. W. S. P.

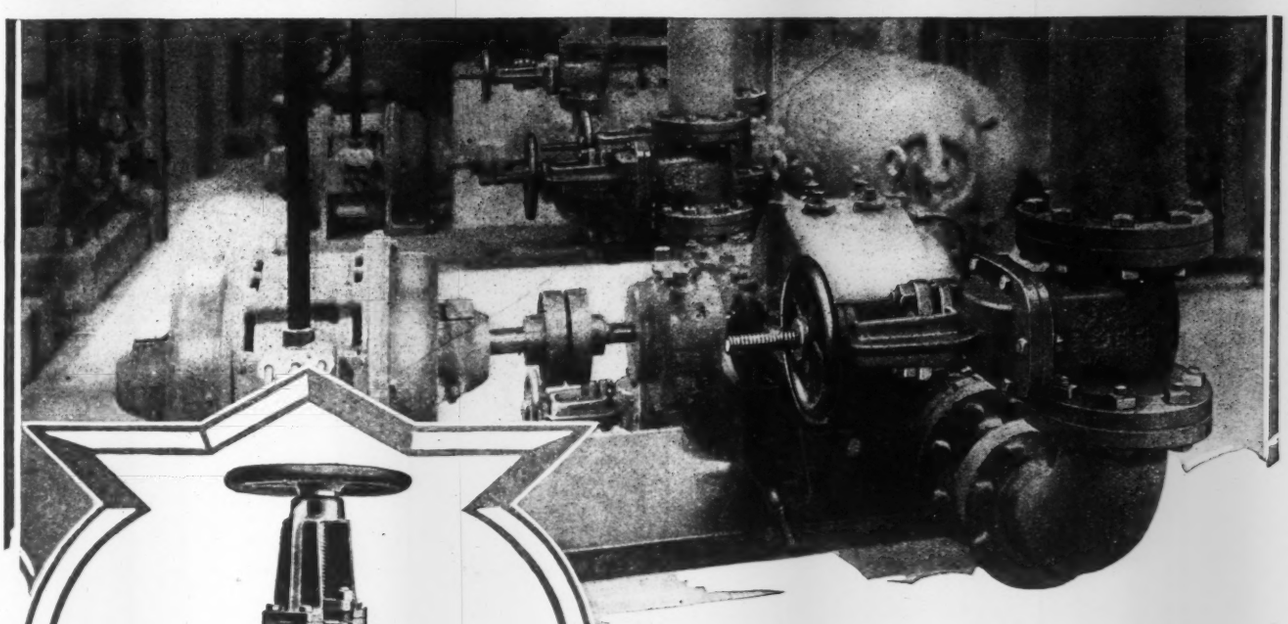
The following Central Power Stations and Industrial Plants have installed Lunkenheimer Steel Valves

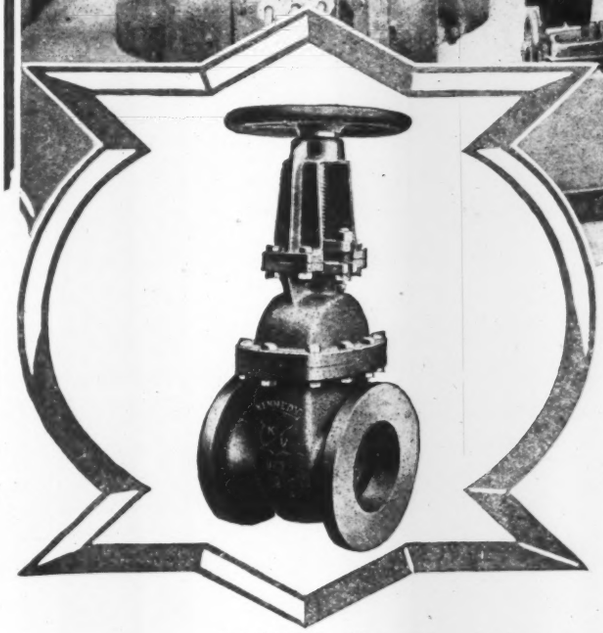
Columbus Railway, Power & Light Co., Columbus, Ohio.
Illinois Electric Power Co., Peoria, Ill.
United Light & Power Co., Davenport, Ia.
Nebraska Power Co., Omaha, Nebr.
Columbia Power Co., Columbia, Ohio.
Philadelphia Electric Co., Philadelphia, Pa.
Long Island Lighting Co., Northport, N. Y.
Narragansett Electric Light Co., Providence, R. I.
Dow Chemical Co., Midland City, Mich.
San Antonio Public Service Co., New Braunfels, Texas.
Portland Electric Co., Portland, Ore.
Anaconda Copper Co., Perth Amboy, N. J.
Connecticut Light & Power Co., Devon, Conn.
Detroit Edison Co., Trenton Channel, Mich.
Detroit Edison Co., Marysville, Mich.
Reynolds Tobacco Co., Richmond, Va.
Peoples Gas & Electric Co., Mason City, Iowa.
Detroit Public Lighting Commission, Detroit, Mich.
General Engineering & Management Corp., St. Petersburg, Fla.
Potomac Electric Power Co., Bennings, D. C.
Solvay Process Co., Syracuse, N. Y.

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U.S.A.
NEW YORK CHICAGO BOSTON PITTSBURGH
SAN FRANCISCO NEW ORLEANS
LONDON
EXPORT DEPT. 129-135 LAFAYETTE ST., NEW YORK

15-35-4

KENNEDY





For security in pipe line control

WHEN Kennedy Valves are closed, they are tight without the necessity of excessive pressure on the stem. Frequent operation does not impair their efficient action, and long periods of idleness do not cause them to stick or bind.

The special operating mechanism and selection of materials for stem, seats and guides assure reliable and long-continued effective operation. We do not know the age limit of Kennedy Valve usefulness for many of the earliest Kennedys are still in active service after a third of a century and more.

These records are a dependable guide for your valve selection. The extensive Kennedy line of over 5000 different types and sizes enables us to meet practically every service and pressure requirement. Send for catalog.

THE KENNEDY VALVE MFG. CO., ELMIRA, N.Y.

BRANCHES:
NEW YORK CITY: 128-132 White St.
BOSTON: 47 India St.
CHICAGO: 228 N. Jefferson St.
SAN FRANCISCO: 448-450 Tenth St.

SALES OFFICES:
Philadelphia
Cleveland
Atlanta
Kansas City, Mo.
Salt Lake City
El Paso
Los Angeles
Seattle

THE
LIBERTY
VALVE OPERATOR

The reliable remote control for gate valves

Every gate valve 6 in. and over in size on high or low pressure steam, water, oil, gas or air lines can be positively and safely controlled from a conveniently located central switchboard or from any one of a number of safety stations in your plant by equipping these valves with the LIBERTY VALVE OPERATOR.

It protects the valve from damage. A limit switch and safety clutch make overtravel impossible. The motor is entirely enclosed and is steam, water and dust proof. Red and green indicator lights show whether the valve is opened or closed. Either push button relay control or manually operated switches may be provided.

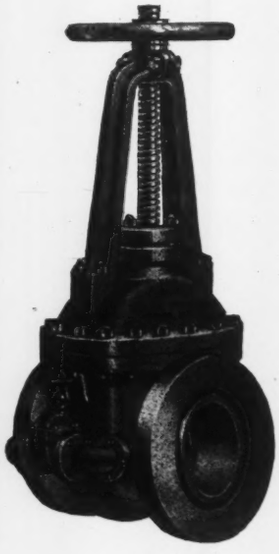
The Liberty Operator fits the standard yoke pads.

Ask us to furnish complete information.
Send now for Circular M-116.

Liberty Electric Corporation
Stamford, Conn.

New York Pittsburgh Chicago Detroit
Cleveland Denver Boston

LUDLOW VALVES



For
High Pressure
Steam
Water, Oil and
Natural Gas
Fire Hydrants
Indicator Posts
Sluice Gates
Check Valves
Foot Valves

THE LUDLOW VALVE MFG. CO.
TROY, N. Y.

BRANCHES: New York, 62 Gold Street; Boston, 1112 Tremont Bldg.; Philadelphia, Harrison Building; Pittsburgh, 815 Oliver Bldg.; Chicago, 731-733 The Rookery; Kansas City Office, R. A. Long Bldg.

Southern Representative:
W. F. Wilcox, Fourth Nat'l Bank Bldg.
Atlanta, Ga.

1

Chapman Valves
Designed and Built to Meet Every Requirement

The Chapman Valve Mfg. Co.
Indian Orchard, Mass.

BRANCH OFFICES:
New York Pittsburgh Chicago Cleveland
Boston Philadelphia Detroit Tulsa
Los Angeles San Francisco Milwaukee

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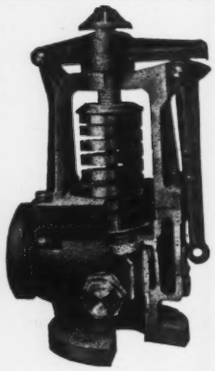

ASHTON
POP VALVES and GAGES

Recognized for their absolutely dependable quality.

Used in the leading high pressure power plants.

Send for Catalog No. 18 which tells all about the full line of ASHTON Specialties.

The Ashton Valve Co.
BOSTON NEW YORK CHICAGO
SAN FRANCISCO

2

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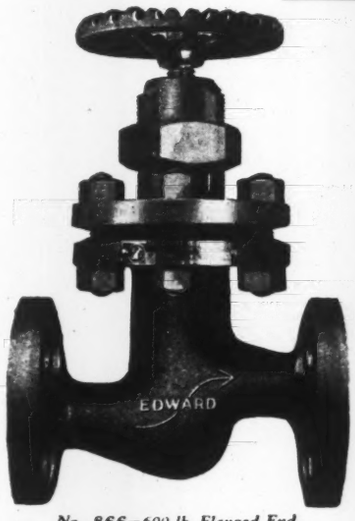
—for Forged Steel Valves?



No. 866—600 lb. Flanged End, Flanged Bonnet, O. S. & Y. Globe Valve

Why EDWARD of course!

For fourteen years **Edward forged steel** valves have been marketed as a standardized product.

Even as pioneers, Edward fostered the principle of general use of **forged steel** small valves in preference to valves of cast materials.

This theory is now finding great favor as indicated by the wholesale selection and very definite preference for **forged steel** in the moderate classes of service as well as the more severe.

Edward continued leadership is evidenced by its variety of advanced designs.

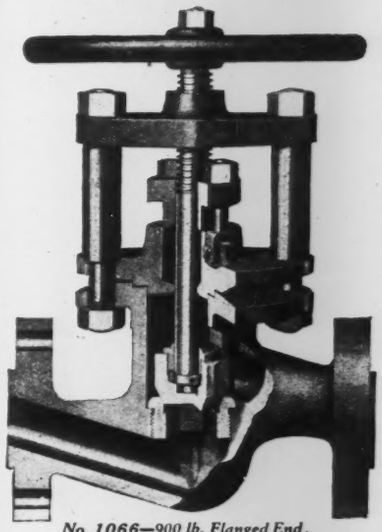
Therefore—if it is **forged steel valves** you want—put your requirements up to Edward.

Complete data and prices sent upon request.

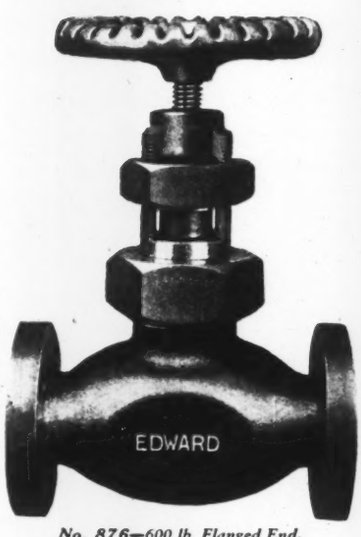
The Edward Valve & Manufacturing Co.

East Chicago, Indiana

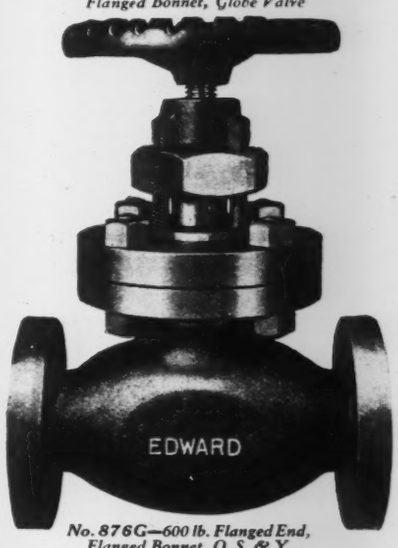
Representatives in all principal cities.



No. 1066—900 lb. Flanged End, Flanged Bonnet, Globe Valve

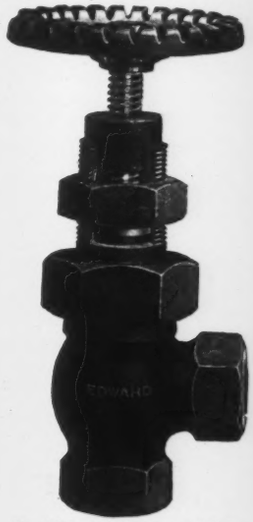


No. 876—600 lb. Flanged End, Union Bonnet, O. S. & Y. Globe Valve



No. 876G—600 lb. Flanged End, Flanged Bonnet, O. S. & Y. Globe Valve

No. 682—500 lb. Screwed End, Union Bonnet Globe Valve

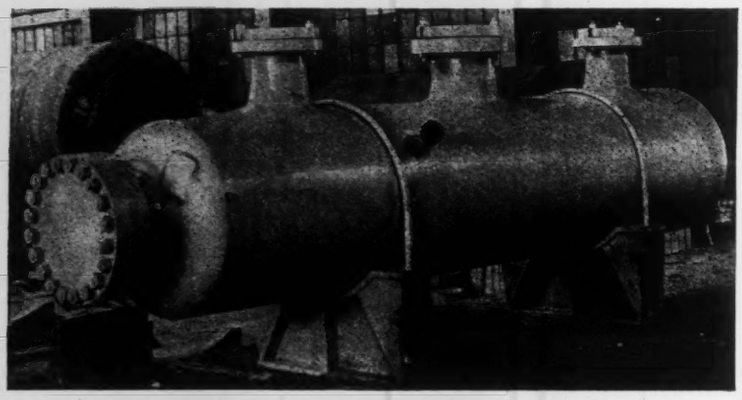


No. 681—500 lb. Screwed End, Union Bonnet Angle Valve

No. 680G—500 lb. Screwed End, Flanged Bonnet, O. S. & Y Globe Valve

40 in. FORGE WELDED STEAM RECEIVER AT STANTON POWER STATION

American Gas & Electric Co., East Pittston, Pa.



Designed and insured for operation under 730 lbs., 750 degrees temperature.

40" I.D. x 1⅞" thick shell x 16'0" long overall. Shell and heads forge and hammer welded. 18" manhole and 1-14" and 2-9" KELLOGG FORGE WELDED nozzles, (patented flued type.) All outlets machined Sargol in accordance with standards for 900 lbs. working pressure. Tested to 1095 lbs. hydrostatic pressure.

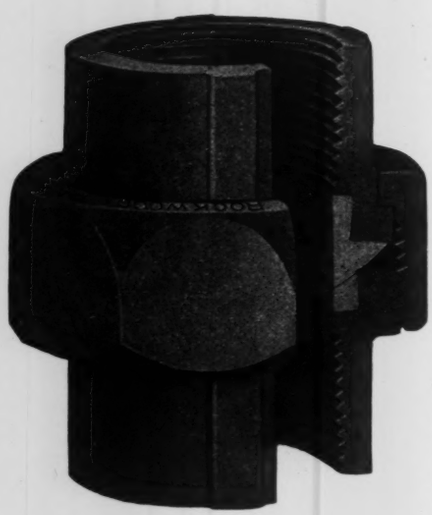
KELLOGG FORGE WELDED equipment is built to conform to the A.S.M.E. Boiler Code and is insurable just as your boilers are insurable.

THE M. W. KELLOGG CO., 7 DEY STREET, NEW YORK, N. Y.

Branch Offices: 101 Marietta St. Bldg., Atlanta, Georgia — 12 Pearl Street, Boston, Mass. — 53 West Jackson Boulevard, Chicago, Ill.

Rockwood Pressed Steel Unions

will not leak or corrode



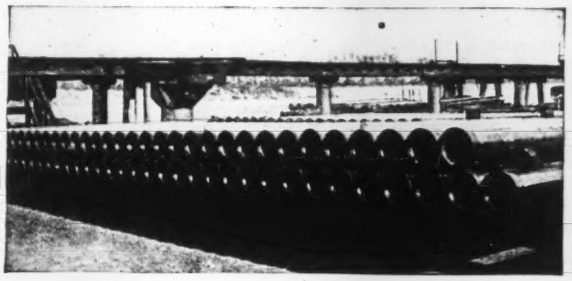
They have the following exclusive combination of features:

1. PRESSED STEEL
   No Seams, Sand or Blow Holes.
2. STRENGTH
   Stronger than any Cast Union.
3. SHERARDIZED
   Absolutely protected from Rust.
4. BRONZE SEATS or MONEL SEATS
   Suitable for every requirement.
5. EXPAND and CONTRACT EQUALLY WITH PIPE
   No leak at the threads.
6. TESTED
   Every Rockwood Union is tested and guaranteed to hold tight.

Manufactured by

Rockwood Sprinkler Company

Worcester, Massachusetts



Cast Iron Pipe and Fittings *for all uses*

Barometric Condensers
Gas Producers
Heavy Castings

Chemical
Sugar House
Miscellaneous

Write for Cast Iron Pipe Handbook.
It contains a wealth of valuable data.

United States Cast Iron Pipe and Foundry Company

Sales Offices
San Francisco, Philadelphia, Pittsburgh, Chicago, Dallas, Birmingham, Kansas City, New York, Cleveland, Buffalo, Minneapolis

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'Tis the usual thing—

when faced with the task of filling a position, to turn to friends they may recommend.

Your *best* friend from whom to seek this help is The Engineering Societies Employment Service. They will refer you to the best available talent for your particular need. The service is free to employers.

Send your requirements to the nearest office of

THE ENGINEERING SOCIETIES EMPLOYMENT SERVICE

Walter V. Brown, Manager

31 West 39th Street, New York
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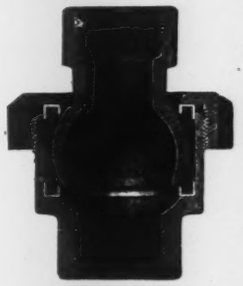
BARCO FLEXIBLE JOINTS

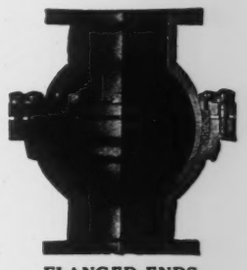
PROVIDE

combined angle and swivel movement with absolute tightness under suction or pressure in any service, including oil, air, steam, water and other liquids or gases.

OVER 1,000,000 IN SERVICE



SCREW-ENDS
¼ to 6 inches



FLANGED-ENDS
4 to 48 inches

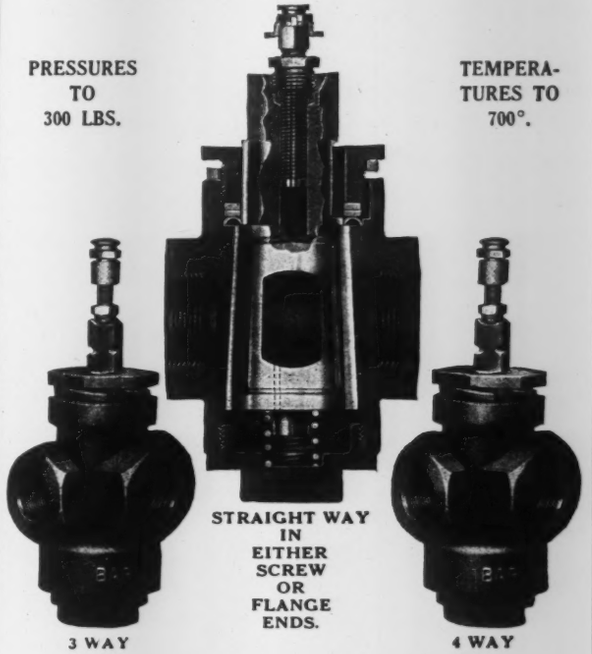
BARCO LUBRICATED PLUG VALVES

PROVIDE

full area, straight passage with one quarter turn of the handle. These valves are balanced by means of the semi spherical steel gasket, preventing the plug sticking in the body, and are provided with a handy method of lubrication, insuring long life and freedom from repairs.

PRESSURES TO 300 LBS.

TEMPERATURES TO 700°.



3 WAY

STRAIGHT WAY IN EITHER SCREW OR FLANGE ENDS.

4 WAY

BARCO MANUFACTURING CO.
1801-1815 Winnemac Ave., CHICAGO, ILL.
THE HOLDEN COMPANY LIMITED
IN CANADA
Montreal—Toronto—Winnipeg—Vancouver

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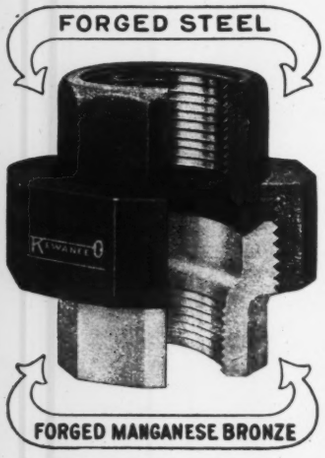
THE KEWANEE UNION



At The New York Power Show

Walworth will have an exhibit of its complete line of brass, iron and steel fittings, valves and tools.

Every single one of them is tested *under water**

NOT one out of a hundred, not one out of ten, but *every* Kewanee Union is separately tested by compressed air under water. This test takes time, but it's worth it to be able to guarantee you a sound, leakless union in every Kewanee you may buy.

Kewanees can't corrode because there is nothing that can rust in the iron-to-bronze thread connection.

The ball-joint is forged manganese bronze to forged steel, impressing a harder upon a softer metal to insure a tight seat.

This eliminates the necessity for a gasket or inserted parts so that there are just the three pieces to make up a joint that won't leak and can't stick.

Kewanees are made to fit all sizes of pipe from ⅛ to 4 inches.

The Kewanee Union has Five Advantages

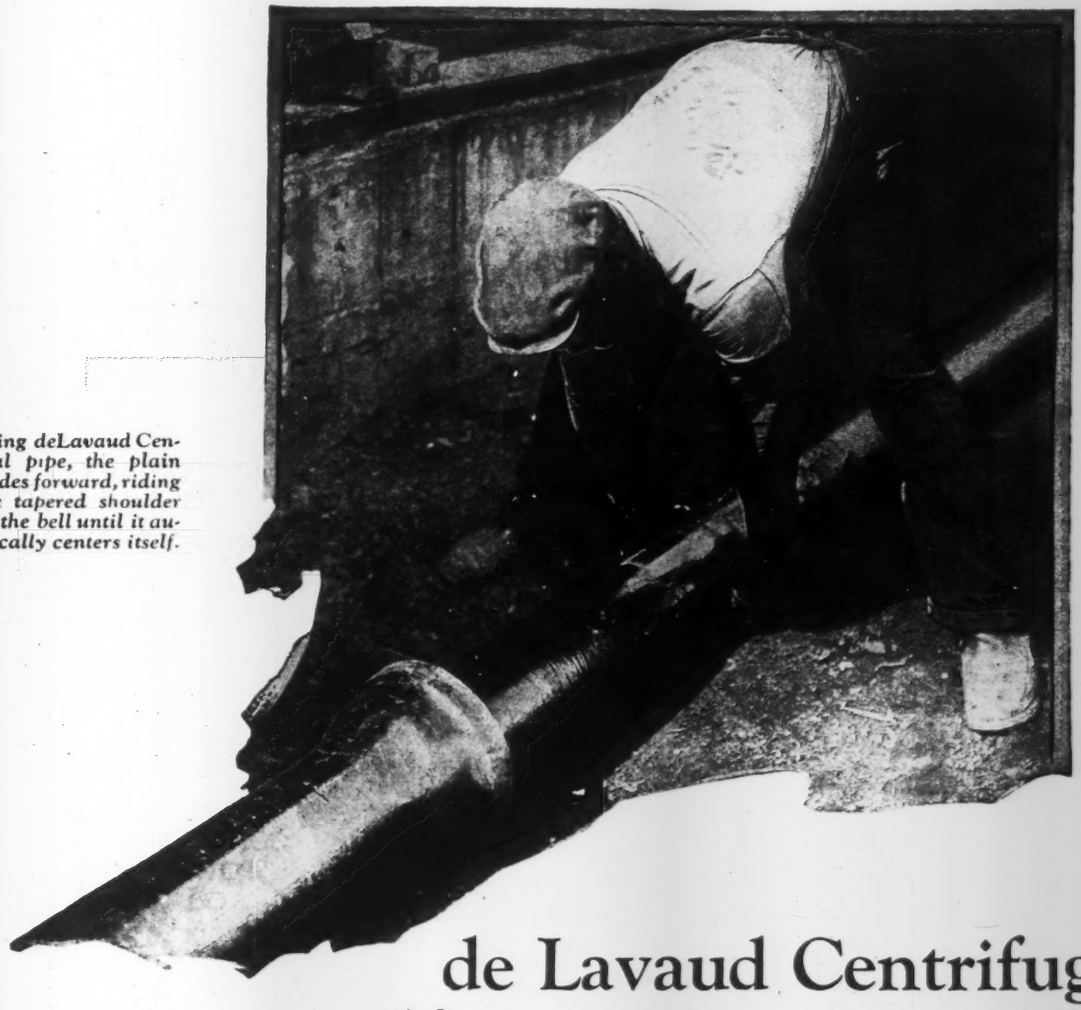
1. No Corrosion
2. No Gasket
3. No Defectives*
4. No Inserted Parts
5. No Force Needed.

WALWORTH COMPANY, Boston, Mass.

Plants at Boston, Kewanee, Ill., Greensburg, Pa., Attalla, Ala. Distributors in Principal Cities of the World.

WALWORTH

"WHATEVER YOU BUILD, YOU NEED WALWORTH"



In laying deLavaud Centrifugal pipe, the plain end slides forward, riding on the tapered shoulder inside the bell until it automatically centers itself.

de Lavaud Centrifugal pipe is self-centering—easy to lay

UNITED STATES CAST IRON PIPE & FOUNDRY CO.
Makers of
deLavaud
Centrifugal
Cast Iron Pipe

THIS pipe is equipped with bell and plain end joint similar to the type used by the Metropolitan Water Board of London, England. Once in place and caulked in the usual manner, these joints show unusual resistance to blowing out and are most flexible.

Write for literature covering the specifications and use of deLavaud Centrifugal Cast Iron Pipe

United States Cast Iron Pipe and Foundry Company

General Offices:
Burlington, New Jersey

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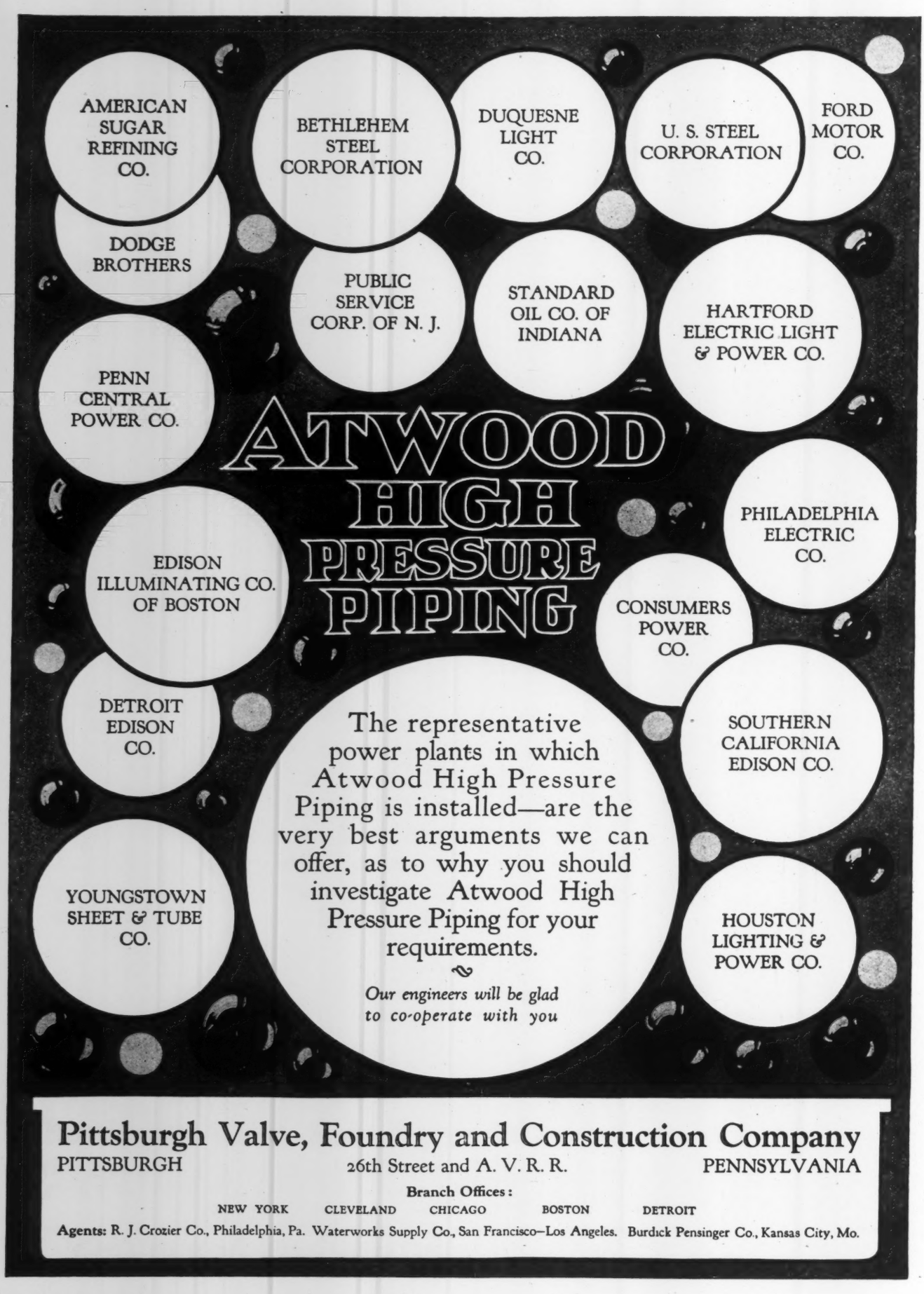
Philadelphia: 1421 Chestnut St.
Chicago: 122 So. Michigan Blvd.
Birmingham: 1st Ave. & 20th St.
Buffalo: 975 East Ferry Street
Cleveland: 1150 East 26th Street
New York: 71 Broadway
San Francisco: 3rd & Market Sts.
Pittsburgh: 6th & Smithfield Sts.
Dallas: Akard & Commerce Sts.
Kansas City: 13th & Locust Sts.
Minneapolis: 6th St. & Hennepin Ave.



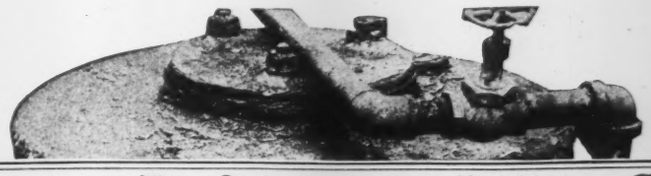
Pittsburgh Valve, Foundry and Construction Company

PITTSBURGH 26th Street and A. V. R. R. PENNSYLVANIA

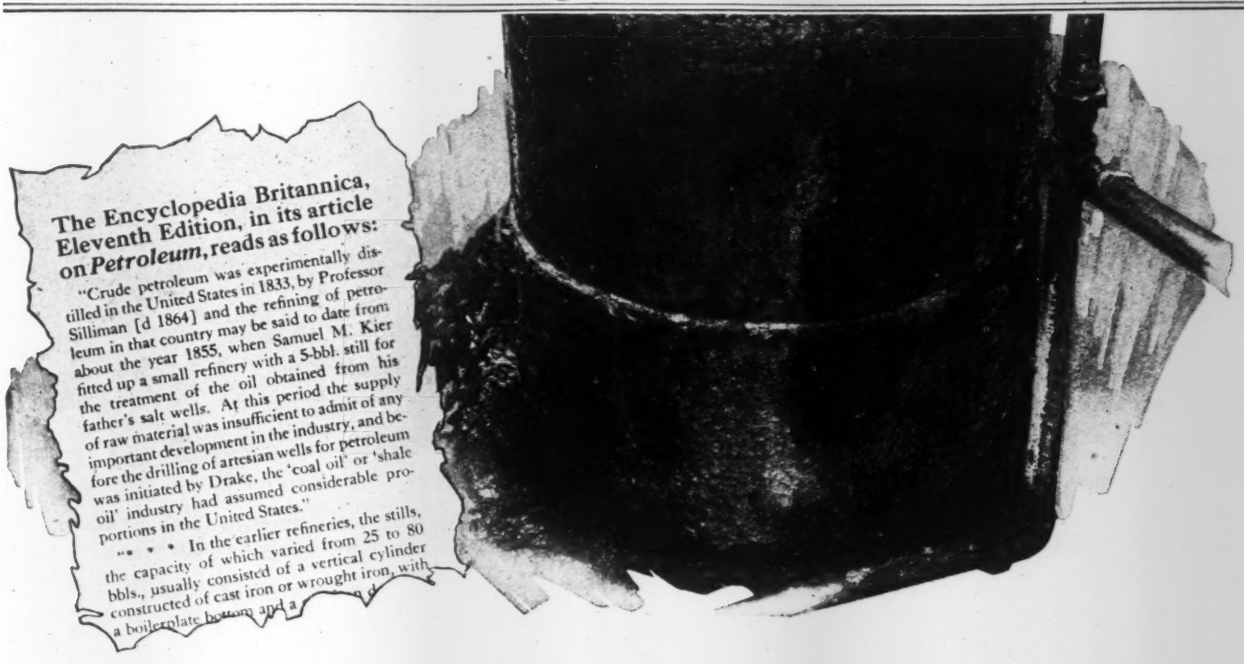
Branch Offices:

NEW YORK CLEVELAND CHICAGO BOSTON DETROIT

Agents: R. J. Crozier Co., Philadelphia, Pa. Waterworks Supply Co., San Francisco—Los Angeles. Burdick Pensinger Co., Kansas City, Mo.



World's First Oil Refinery ~ *Built in 1855 Still in Service*



The Encyclopedia Britannica, Eleventh Edition, in its article on *Petroleum*, reads as follows:

"Crude petroleum was experimentally distilled in the United States in 1833, by Professor Silliman [d 1864] and the refining of petroleum in that country may be said to date from about the year 1855, when Samuel M. Kier fitted up a small refinery with a 5-bbl. still for the treatment of the oil obtained from his father's salt wells. At this period the supply of raw material was insufficient to admit of any important development in the industry, and before the drilling of artesian wells for petroleum was initiated by Drake, the 'coal oil' or 'shale oil' industry had assumed considerable proportions in the United States."

"* * * In the earlier refineries, the stills, the capacity of which varied from 25 to 80 bbls., usually consisted of a vertical cylinder constructed of cast iron or wrought iron, with a boilerplate bottom and a [illegible]

Such is Durability *of* Wrought Iron

A MODEST wrought iron tank, standing four feet, eight inches high, with a few simple pipe connections—the world's first oil refinery!

This is the historic 5-bbl. still referred to in the Encyclopedia Britannica as being used by Samuel M. Kier seventy-one years ago, for refining the strange fluid which spoiled his father's salt wells.

This venerable relic may still be seen doing duty as a separator at a gas well near Salina, Pa. Considering the severe corrosive conditions to which it has been exposed, one wonders that there is still a crumb of it left intact. But there it is, much battered by Father Time, yet doing its bit every day as of old.

As any old-timer will tell you, only wrought iron could last that long.

That's why Byers Pipe, now as in the early days of this old relic, is made from the same honest, old-fashioned metal—genuine wrought iron—famed since antiquity for its enduring worth.

Slowly and laboriously it is produced, this metal, in order that there may be built into it the rust-defying quality which so surely protects costly installations against the havoc of pipe failures.

With every passing year, the dependability of Byers Pipe in heating, plumbing, water supply, drainage and power systems becomes more clearly demonstrated. Against the slightly higher first cost of a Byers installation is the definite assurance of double life in service.

A. M. BYERS COMPANY
Established 1864 **Pittsburgh, Pa.**

New York	Philadelphia	Boston
Chicago	Los Angeles	Cleveland
Cincinnati	Rochester	Kansas City
Tulsa	Houston	Jacksonville
	Birmingham	

Distributors in All Jobbing Centers

the *Spiral Stripe*
protects you against mistakes and substitution
Also look for name and year rolled in metal

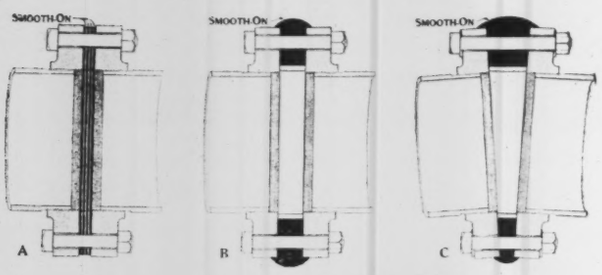
BYERS PIPE

GENUINE WROUGHT IRON

Where joints will not meet use SMOOTH-ON

IF it's merely a matter of getting the joint together when the flanges almost meet, (A), pad out the gasket space with several gaskets liberally coated with Smooth-On No. 3.

If the flanges are very far apart (B), put in a short sawed section of pipe between them (see diagram), use extra long bolts and pack in with Smooth-On No. 1. After the Smooth-On has taken an initial set, draw the bolts a little tighter.



If it's a case of hopeless misalignment (C), redrill the bolt holes (if necessary), fit a wedge-shaped section of pipe as before, put the bolts in and fill the whole joint with Smooth-On No. 1.

With either of the latter methods, the finished Smooth-On joint becomes virtually solid with the line, expands and contracts in unison with it and resists any pressure that the pipe itself will stand.

For detailed instructions on the above jobs and many others that every Engineer should know about, see the Smooth-On Handbook.

Get Smooth-On No. 3 in 1 or 5-lb. can, and Smooth-On No. 1 in 1 or 5-lb. can, or 25, 50 or 100-lb. keg from your nearest dealer or if necessary from us direct.

This BOOK FREE if you mail the coupon

Twentieth Edition—Completely rewritten—136 pages of new data—193 diagrams, pictures and practical hints on at least 200 different uses for SMOOTH-ON. Every progressive engineer should have this book—get your copy NOW.

Smooth-On Mfg. Co., Dept. 56, 570 Communipaw Ave., Jersey City, N. J.
Please send copy of the **Smooth-On** Handbook, 20th Edition.

Name .....

Address .....

Do it with SMOOTH-ON

"Thorough heat insulation always pays for itself"

HENRY ADAMS, *a leading consulting mechanical engineer of Baltimore. Many of the most important power and heating installations in the Baltimore territory have been made under Mr. Adams' direction.*

"IN designing the heating system of the Maryland Casualty Company," said Henry Adams, Consulting Mechanical Engineer in charge, "we aimed to obtain the highest possible efficiency along with economy of upkeep. Each of the buildings of the company is connected by tunnels in which the various piping systems have been placed so as to be readily accessible at all times should repairs be necessary.

"We believe that thorough heat insulation always pays for itself, and for this reason we used extra-thick coverings in certain parts of the system. All high and medium pressure lines are covered with 2" thick 85% Magnesia, while low pressure lines have 1" thick covering. Boiler settings are also insulated with 2" thick 85% Magnesia with a half-inch finish coat of cement. This not only saves fuel and keeps the boiler room cooler, but if there are any leaks in the setting it reduces air leakage to a minimum."

When it came to insulating materials which would measure up to the high standards set by Mr. Adams, Carey Heat Insulations were chosen because the test of actual experience, in heating plants all over the country, has shown Carey Heat Insulations to be unsurpassed. Unsurpassed not only in insulating efficiency, but in lasting durability as well. These superior insulating materials truly pay for themselves —and more—wherever installed. Write for full details.

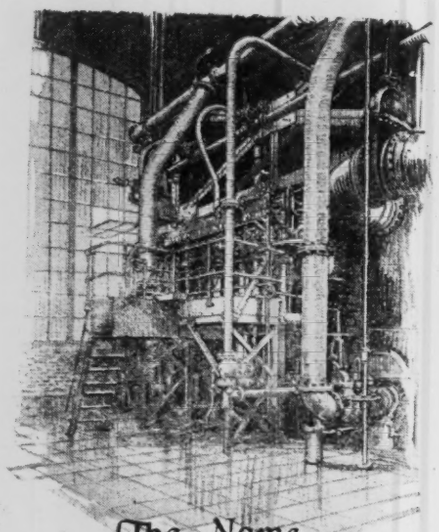
THE PHILIP CAREY CO., *Lockland*, Cincinnati, Ohio

Carey

HEAT INSULATIONS

For every need...from residence to super power plant

GARLOCK
TRADE MARK



The Name
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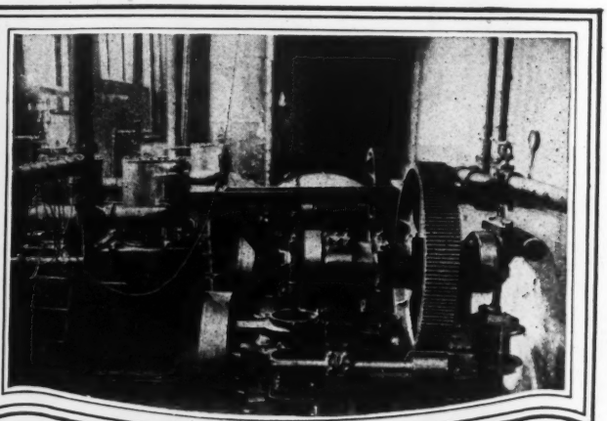

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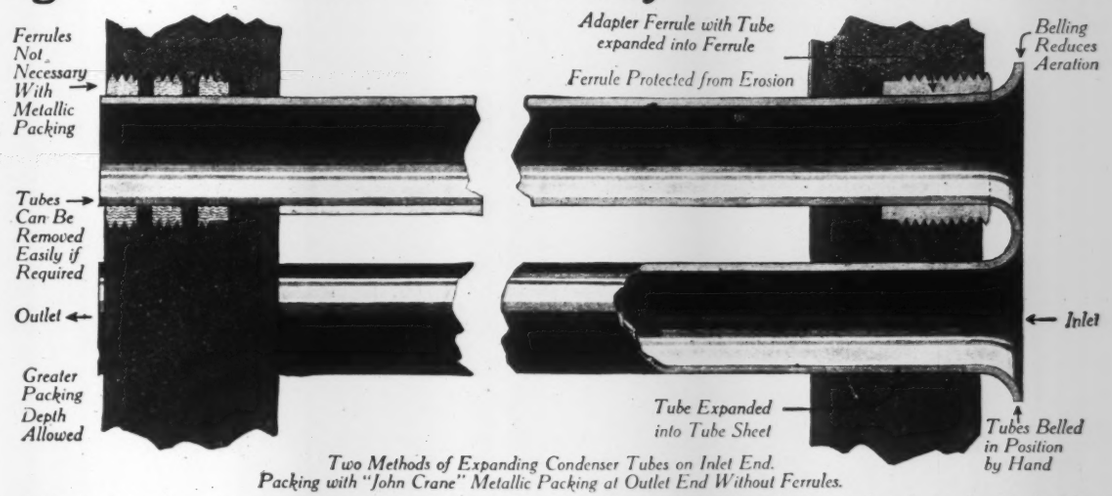

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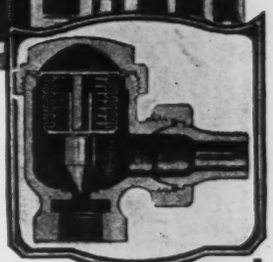

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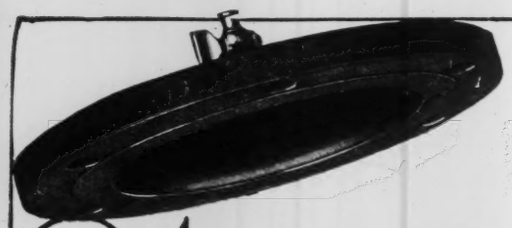

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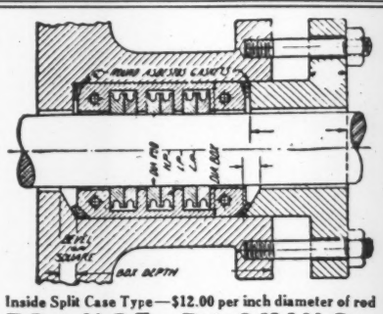

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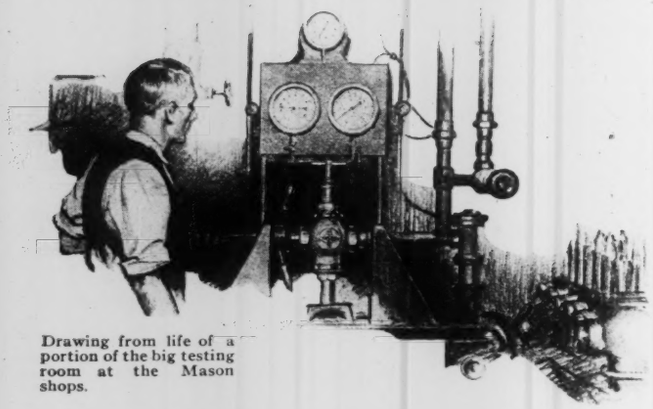

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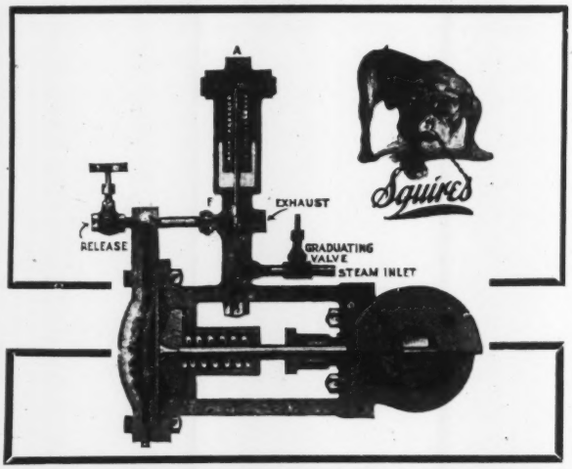

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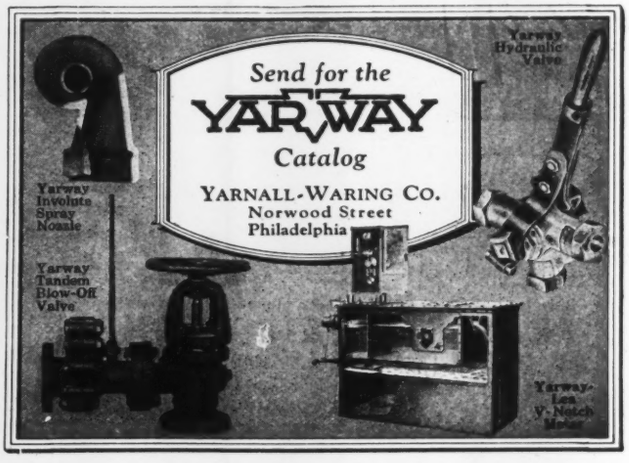
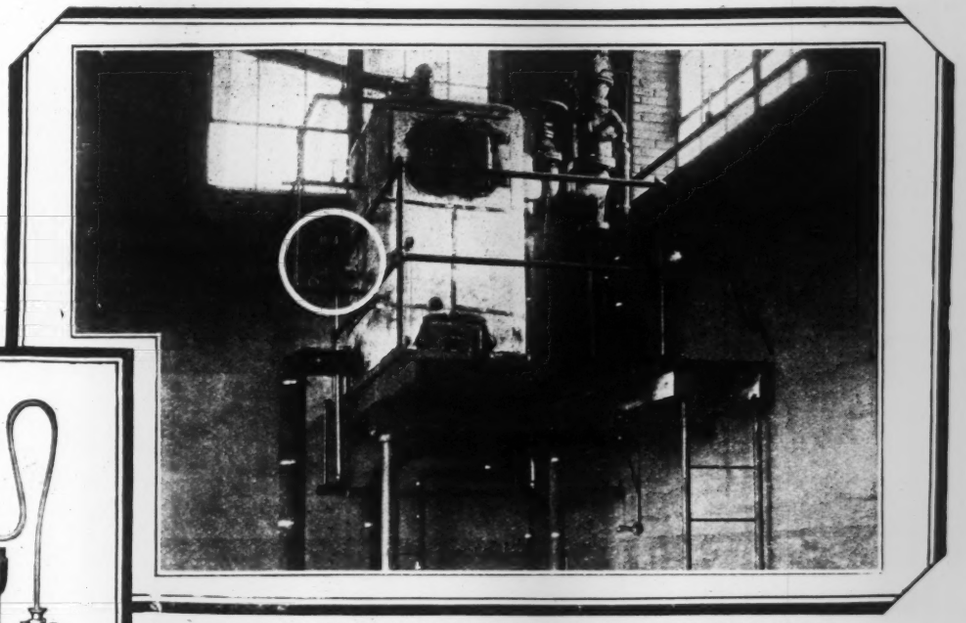
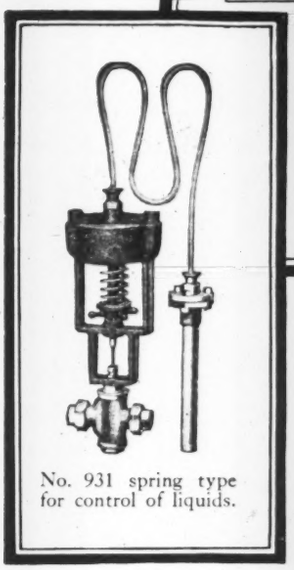




No. 931 Sylphon Temperature Regulator on Feed Water Heater in Charlottesville Woolen Mills, Charlottesville, Va.



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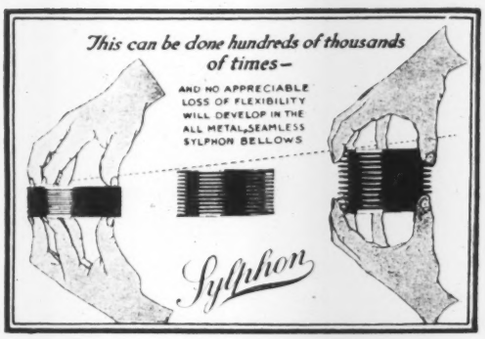

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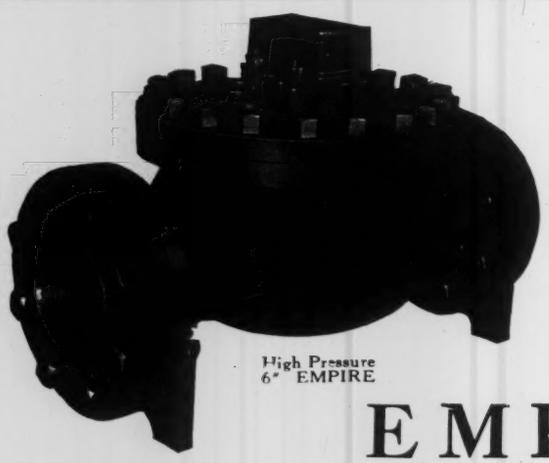

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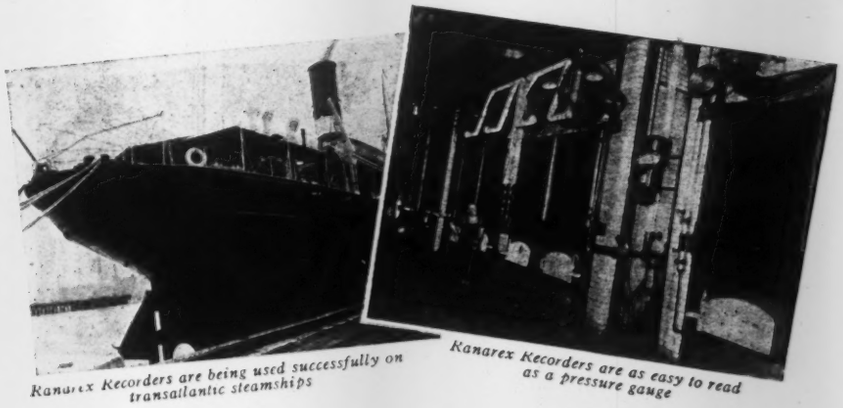

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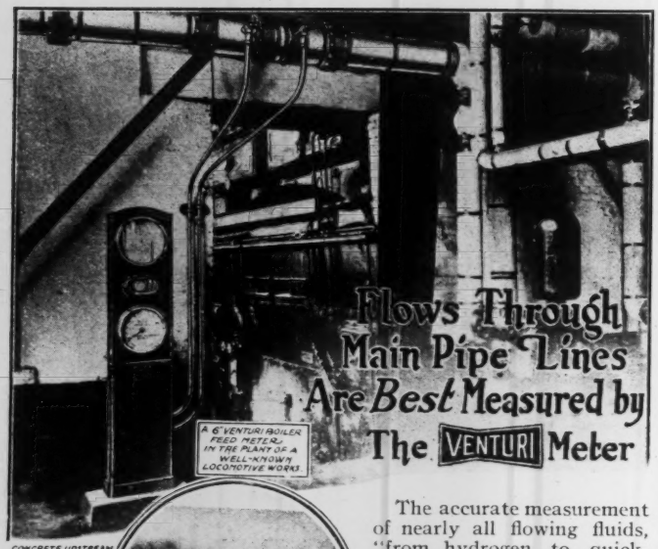

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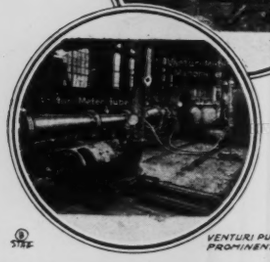
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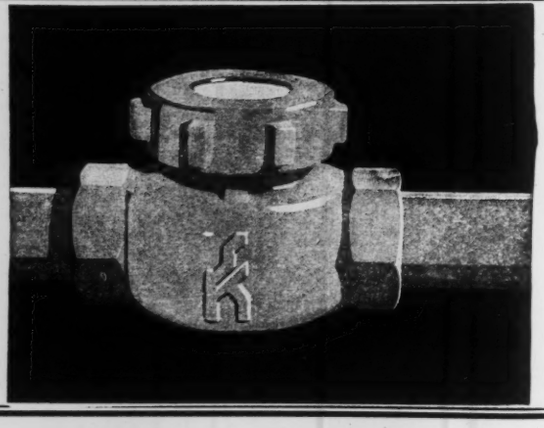

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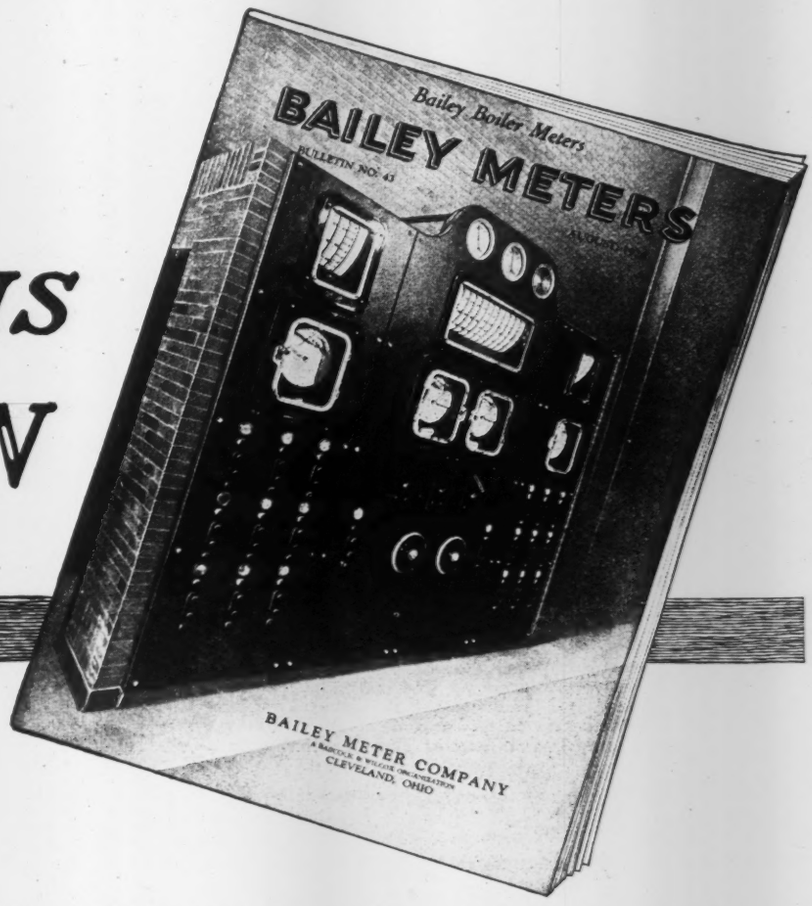

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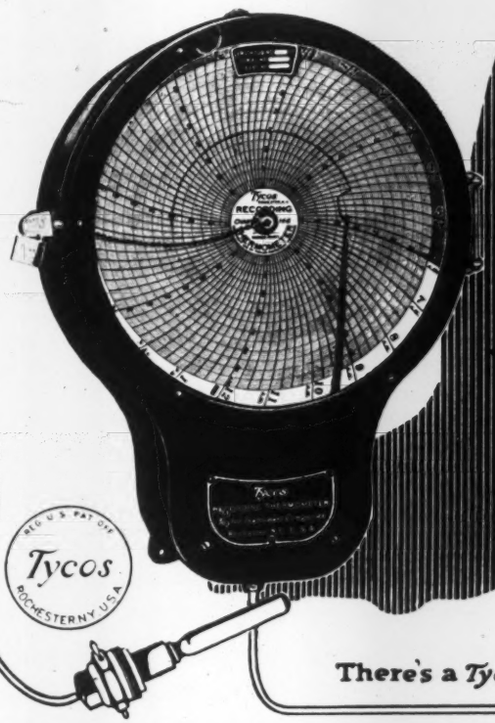

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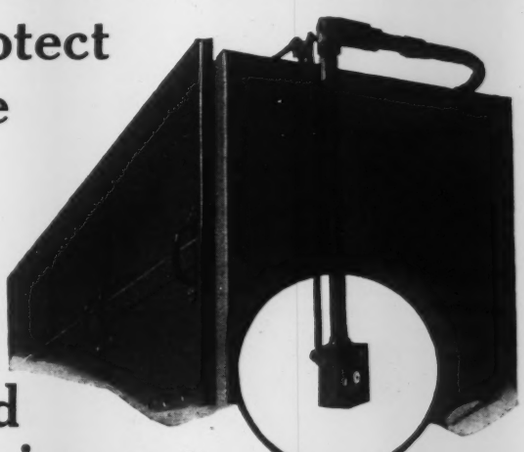

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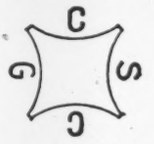

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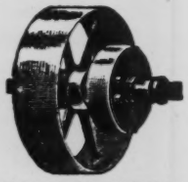

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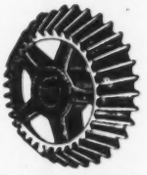

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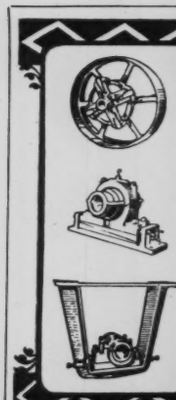

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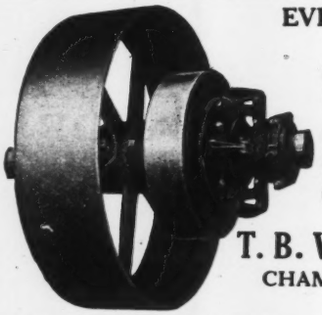

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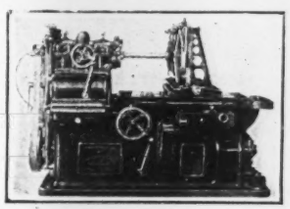

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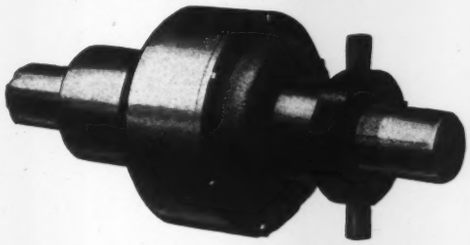

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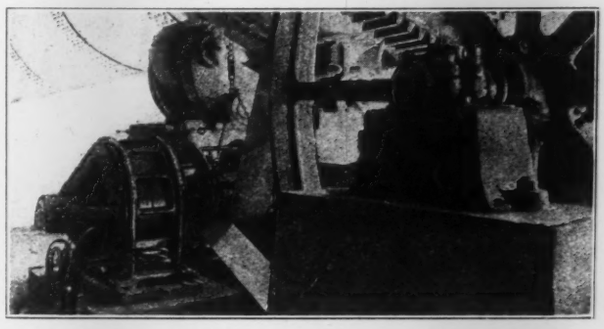

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This "old-timer" has been in operation sixteen years. It is installed in connection with a 50 h.p. motor driving a rotary kiln in a portland cement plant. The kiln operates night and day, practically every day in the year.

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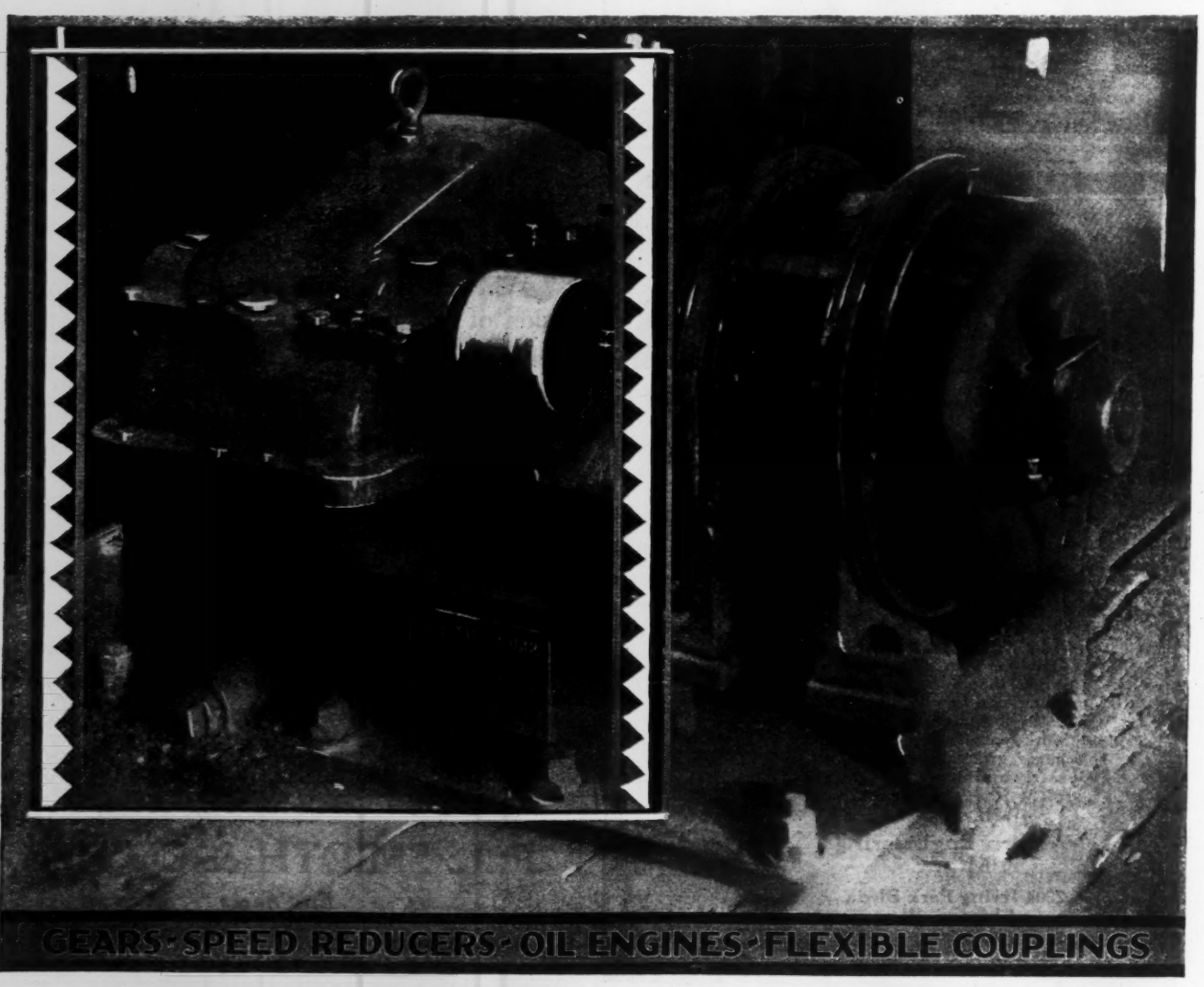

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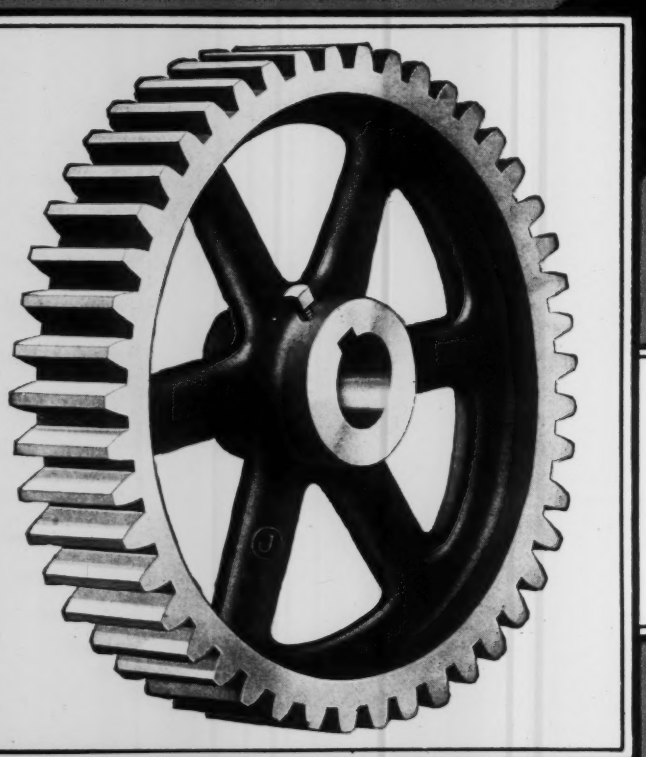

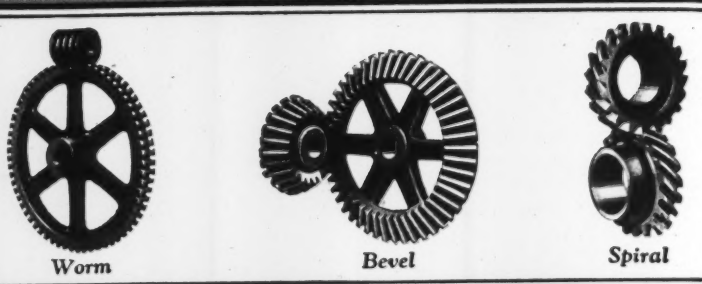

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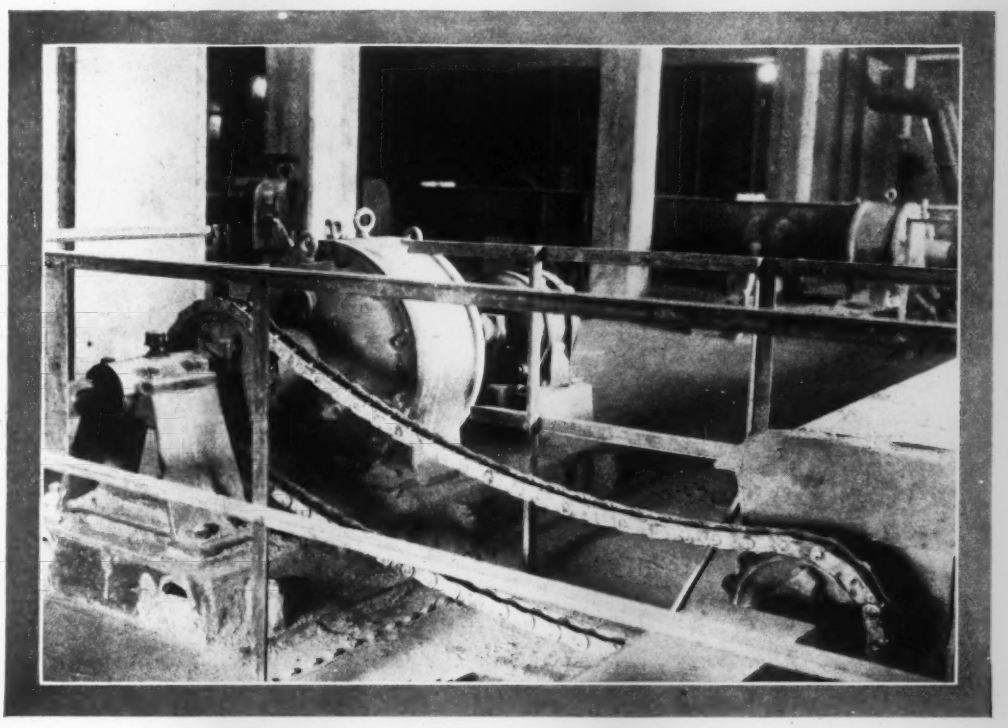
Jones Industrial Gears



ANY CONDITION IS IDEAL

For a Jones Spur Gear Speed Reducer there are no bad working conditions. Dust and grit can not reach the gears operating inside the cast iron housing.

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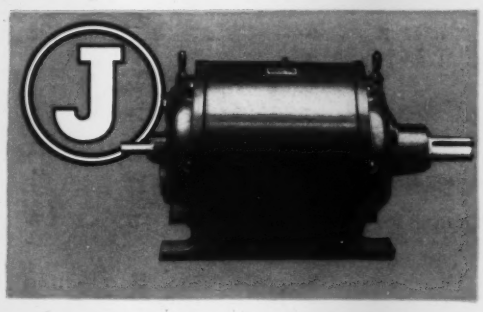

With all gears enclosed, Jones Reducers are safe even for careless workmen. With oil-tight as well as dust-proof housing, the Jones Reducer is as fitted for the spotless room of a food plant as for the grimy interior of a coke plant.

A wealth of practical experience has been built into this balanced straight line drive reducer. Get complete information. Write today for Jones Catalog Number 26. It's an authority.

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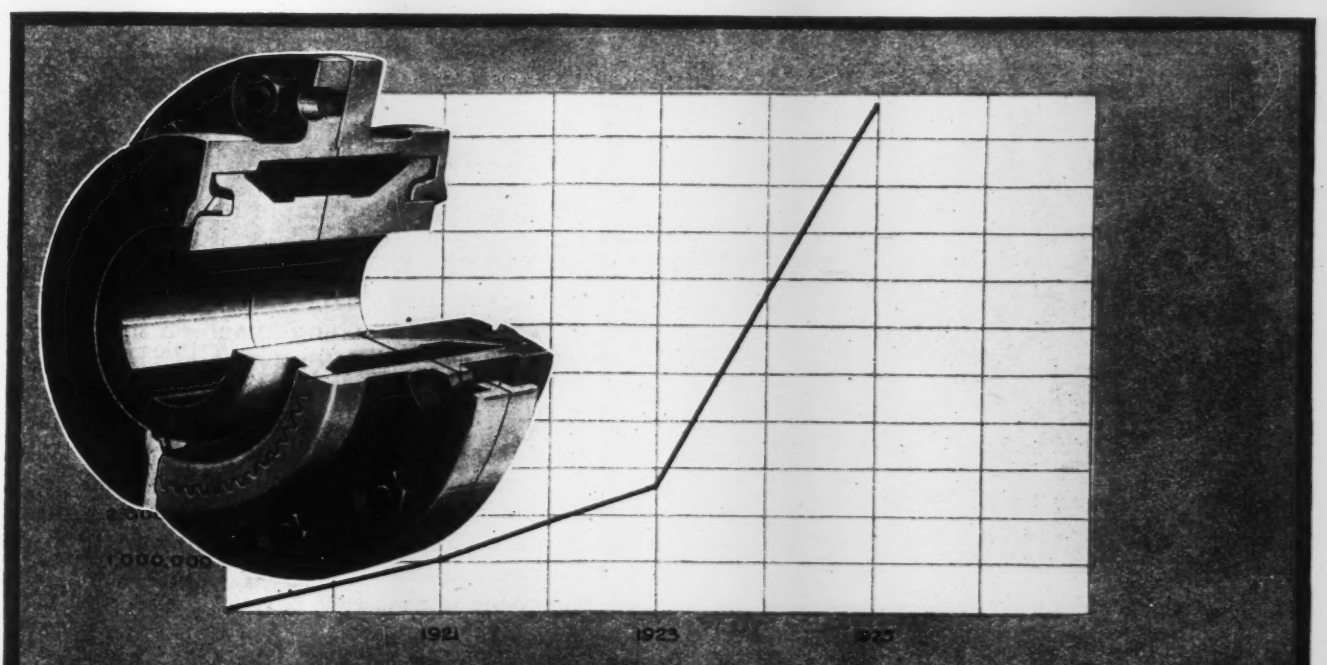
Jones Speed Reducers



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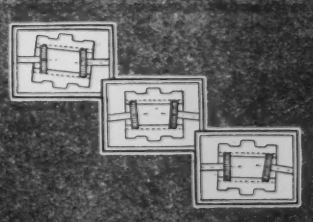

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Two generated spur gears, one on each shaft end, are continually and completely meshed in oil with the internal gears of a floating sleeve. The shafts and sleeve revolve as one unit, allowing the connecting sleeve free lateral and angular play.

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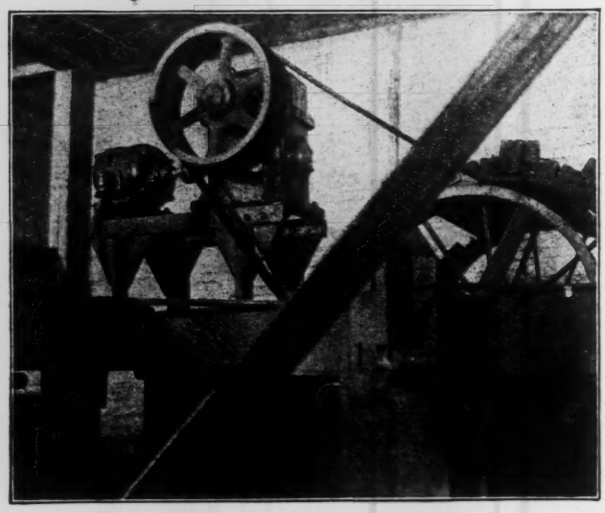

FOR THE OVERHUNG LOAD

This is a typical example of the kind of a load that a HORSBURGH & SCOTT WORM GEAR SPEED REDUCER will carry. The unit illustrated is our Series 1600 Type WB driving a mould washing machine in a large brick plant. The motor is 10 H. P. at 875 R. P. M.—Speed Reduction 25 to 1.

It is the oversize solid bronze journal bearings which allow an overhung load of this type to be economically and efficiently carried.

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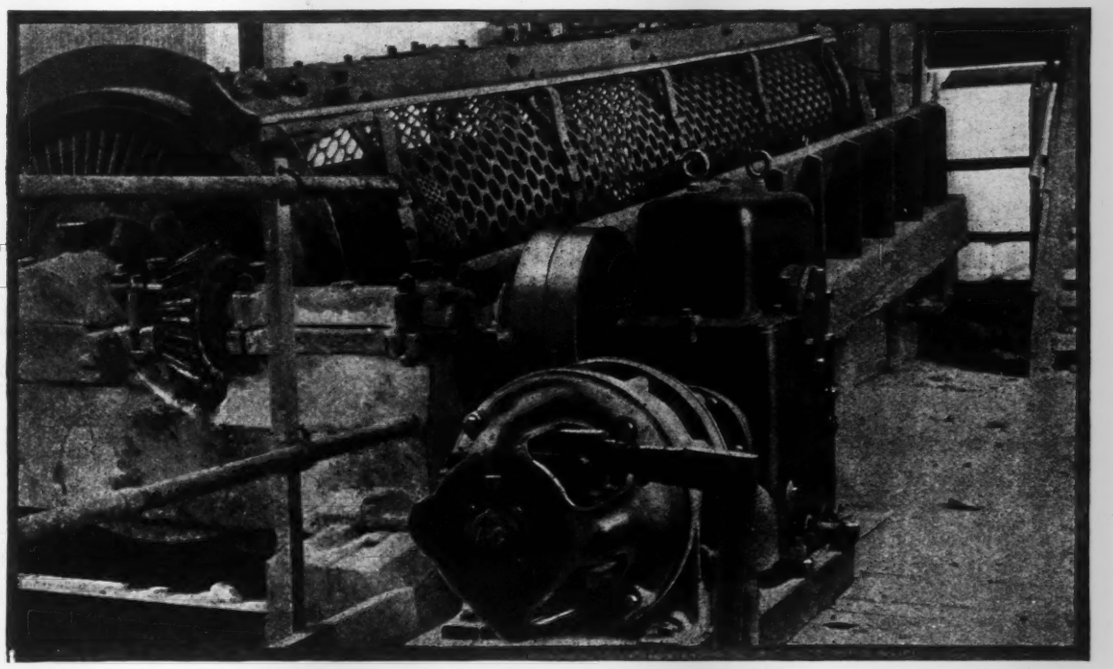
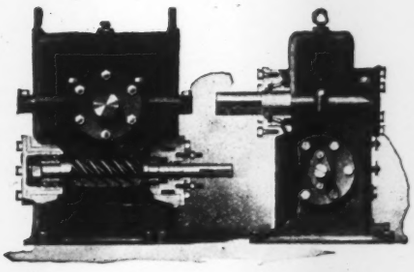


One of five Cleveland Worm Gear Reduction Units driving sizing screens at the Lake Erie Limestone Co.

Cleveland Drives for Rough Service



A Cleveland drive is the best and most economical insurance against shut-downs. Neglect of the connecting link between the motor and the driven machine has reduced profits in too many plants. Bridge that gap with a Cleveland and it will pay real dividends for years.

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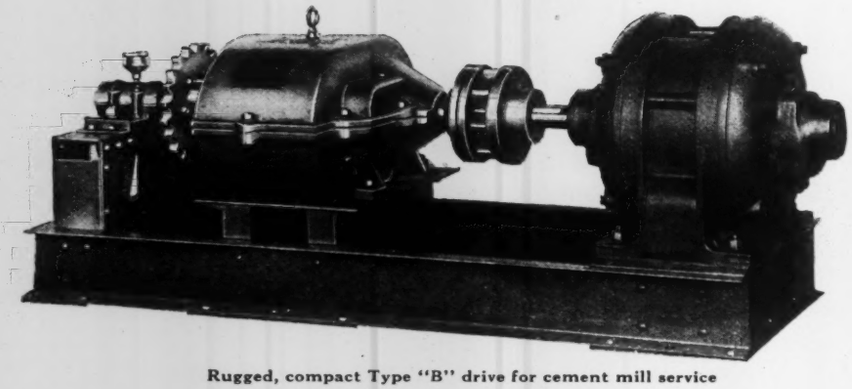
You will find the Cleveland drive a real solution for troublesome power transmission problems. Our engineering experience and the operation records of Cleveland equipment merit your consideration.

"Cleveland Worm Gearing—the Ultimate Drive"

CLEVELAND
WORM & GEAR COMPANY

3263 East 80th Street **Cleveland, Ohio**

Announcing the Improved
PALMER-BEE SPEED REDUCER



Rugged, compact Type "B" drive for cement mill service

See it at Booth 697 New York Power Show

All the good features of the old style Palmer-Bee Reducer have been retained in the design and construction of the new type.

The fundamental principle, which has been proven correct thru years of the most gruelling service, is the same. But, as a result of our experience in practically every basic industry in the country, these changes have been made which add materially to the ruggedness and simplicity of this unique reducer:

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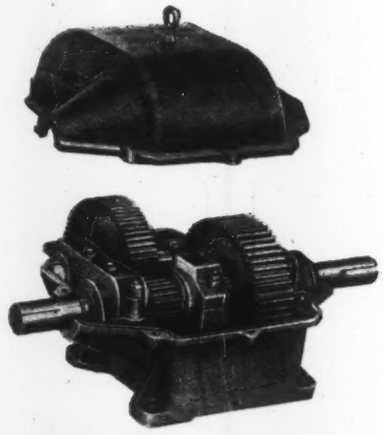
These improvements on the time-tried and proven satisfactory basic principle of the Mill Type Reducer make it the outstanding gear reduction on the market. Visit our exhibit at the Power Show; see and examine it yourself and be convinced of its superiority.

"World's Largest Producers Use P-B Reducers"

PALMER-BEE COMPANY
Detroit, Michigan



No. 160-A Palmer-Bee Reducer with cover removed. Note the extreme ruggedness of construction and complete accessibility of entire mechanism.

Palmer-Bee Speed Reducers

TRADE MILL REG. U.S. P-B MARK TYPE PAT. OFFICE

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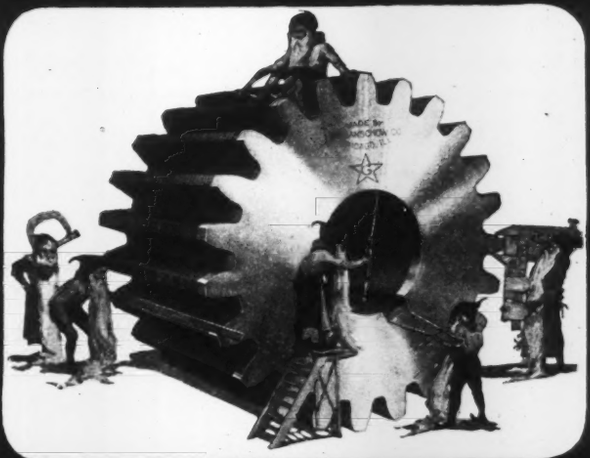

Accuracy

Fabroil (a General Electric product) is a compressed cotton fibre that does not deteriorate with age and is not subject to heat or cold, dryness or dampness.

That noisy waste of metal grating against metal is wholly unnecessary and is overcome by the use of Fabroil Gears and Pinions, which absorb vibration and shock in gear trains.

Fabroil noiseless gears are as strong as the best cast iron and cushion equally well with cast iron, steel or bronze mating gears. They can be run in a bath of oil.

We suggest and recommend Fabroil motor pinions be placed in your stock to avoid unnecessary and costly breakdowns that are bound to occur with short-lived non-metallic gears and steel pinions.

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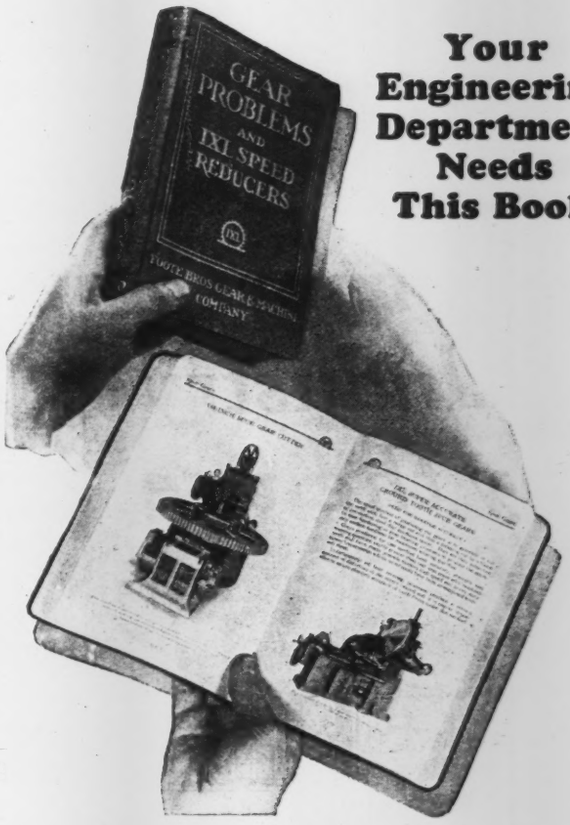

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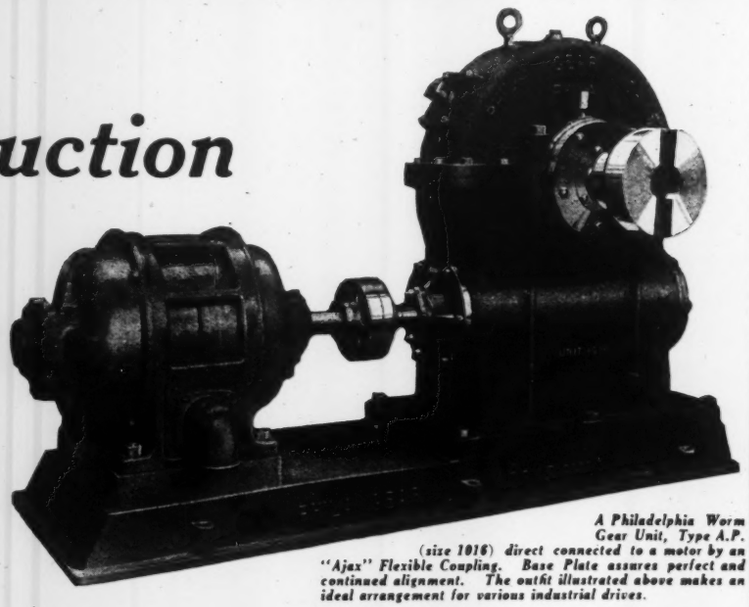

A Philadelphia Worm Gear Unit, Type A.P. (size 1016) direct connected to a motor by an "Ajax" Flexible Coupling. Base Plate assures perfect and continued alignment. The outfit illustrated above makes an ideal arrangement for various industrial drives.

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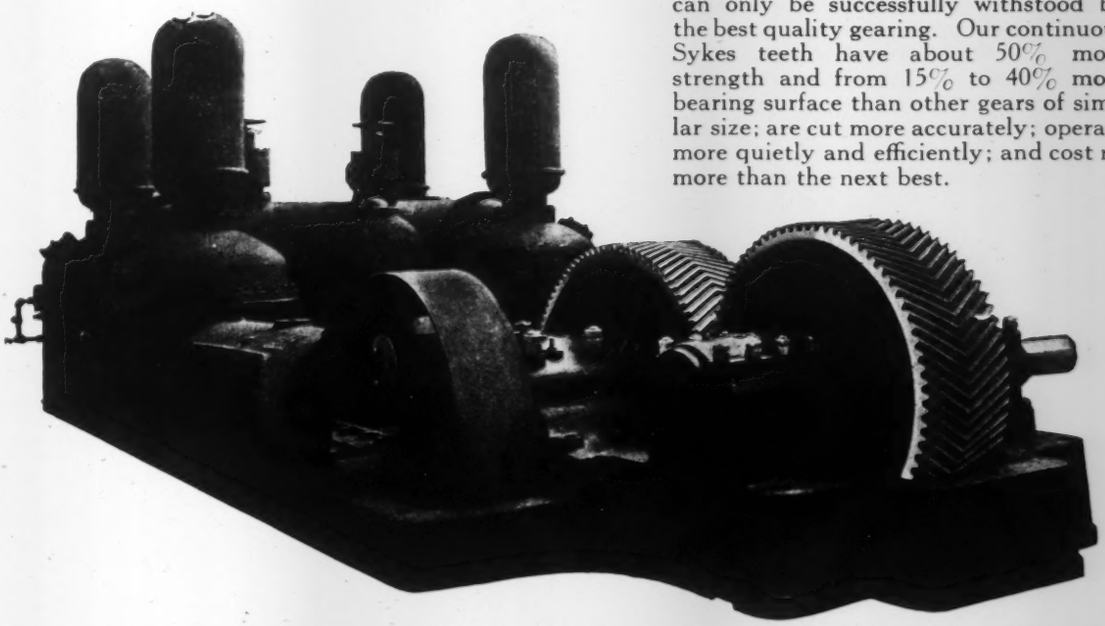

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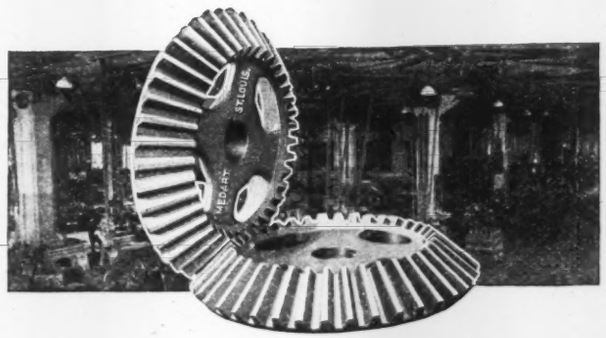

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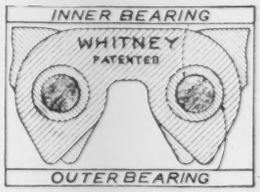

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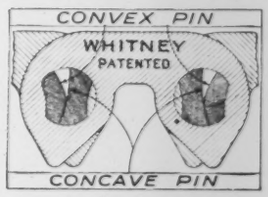

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See our Exhibit in the Fifth National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York, December 6th to 11th, 1926.

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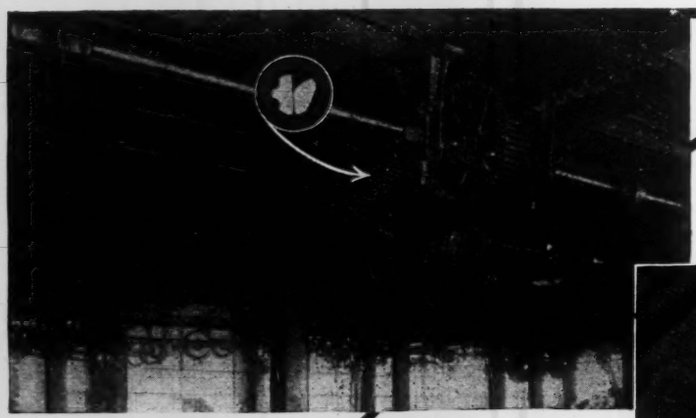
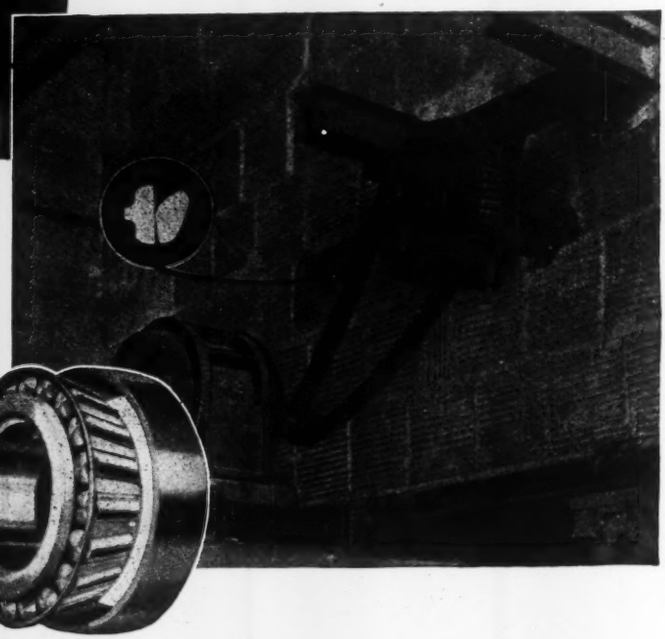


At left, 50 H. P. Morse Silent Chain Drive from motor to lineshaft. Driver, 690 r.p.m.; Driven, 250 r.p.m., 36 inch centers. Below, 7½ H.P. Morse Silent Chain Drive from motor to lineshaft, Bock Bearing Co. Driver, 750 r.p.m.; Driven, 188 r.p.m., 30 inch centers



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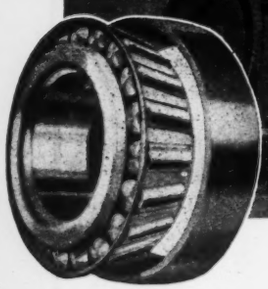

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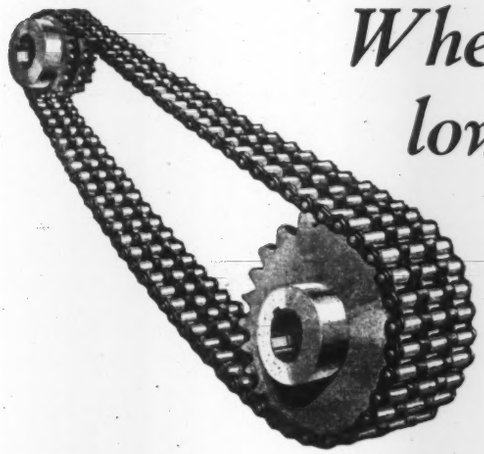

When you think of the ease and low-cost of its maintenance

OCCASIONAL inspection and a little oil--that's all the attention a Diamond Roller Chain ordinarily requires —and it keeps your drive on "roller bearing" efficiency through years of dependable, ***positive*** transmission.

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Add this essential feature of economical and easy maintenance to the advantages listed at the left— and being proven today in thousands of applications —and you will realize that Diamond Roller Chains really *cost less* in the end than belts that slip, or gears that wear, waste power, and grow noisy. They are the ideal link between driving and driven part, both in first cost and maintenance.

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EFFICIENT ON SPEEDS AS HIGH AS 3600 R.P.M.

Rolling in contact with the sprockets—Lowered friction that results in more than 98% efficiency—a power transmission equal to that of silent chains.

Positive drive maintains a consistent speed ratio—None of the "slip" present with belts, none of the lost power and noise due to the sliding friction of worn gear teeth.

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High in efficiency—Long in dependability—Low in maintenance —Low in first cost.

Rolling Surfaces *Prevent Wear*

DIAMOND CHAIN

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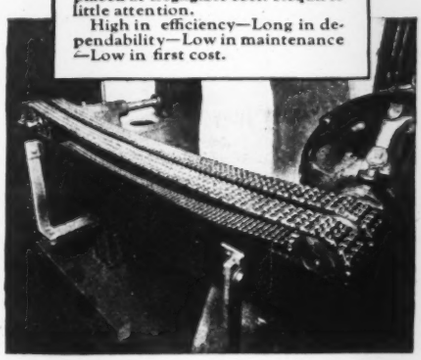

Double, Three-Strand Diamond High Speed Roller Chain on a motor-to-blower drive. Diamond Chain gives more than 98% efficiency of power transmission at speeds as high as 3600 r. p. m.

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Makers of High Grade Chains since 1890

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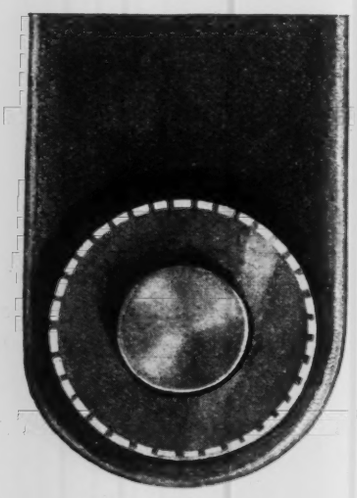
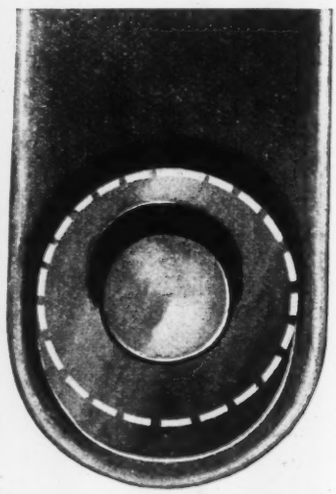


Old Style Combination Chain



Rex Durobar with the added metal

Due to the added metal section placed off center to the pin, in the barrel of the malleable block link of Rex Durobar, the particular source of bad sprocket action of ordinary combination chain is completely overcome. Only the rear barrel engages with the sprocket tooth. The added metal on this barrel serves to thrust the forward barrel forward *out of contact with the sprocket tooth.* In ordinary combination chains it is the forward barrel that grinds.

Fits Standard Sprockets

Rex Durobar is not a special Chain except in its construction. It fits Standard Sprockets. It retains all of the low cost advantages of ordinary combination chain, plus that great advantage which combination chains can never provide, that is, freedom from bad sprocket action.

The relieved and lubricated barrel

Rex Durobar can be furnished either with or without lubrication. The relieved and lubricated barrel has been found especially desirable for use in handling hot or acidulated materials.

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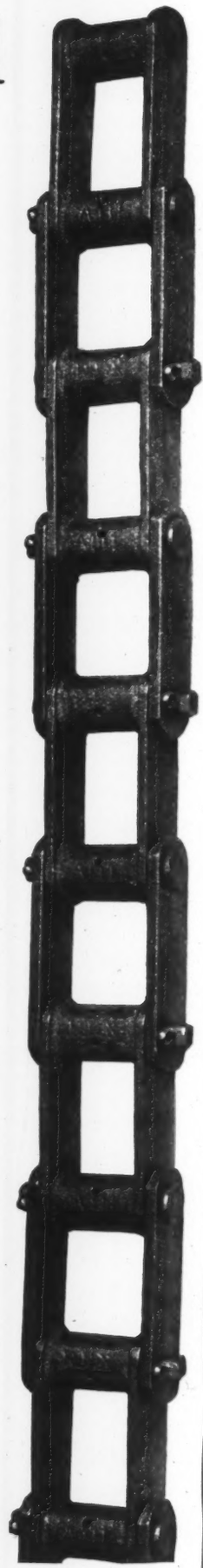

REX CHAIN

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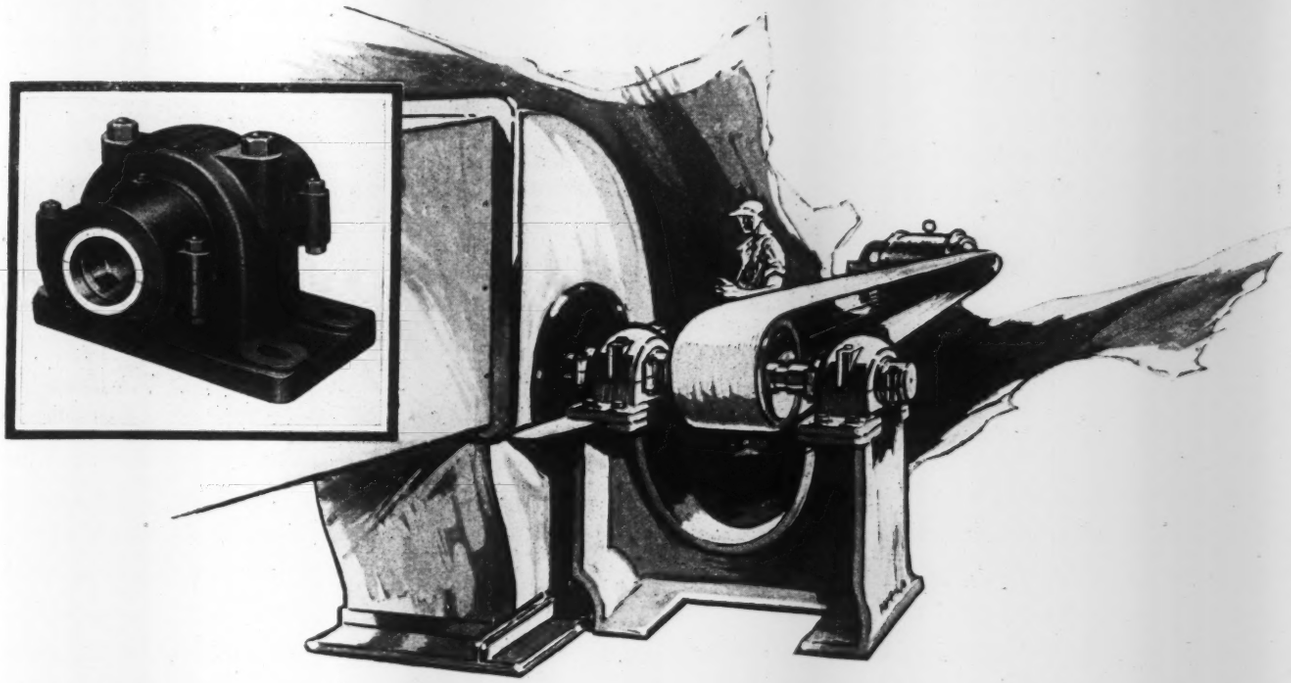

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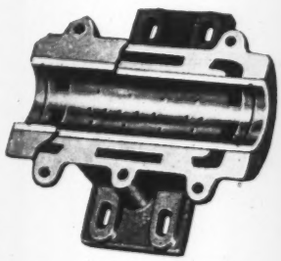

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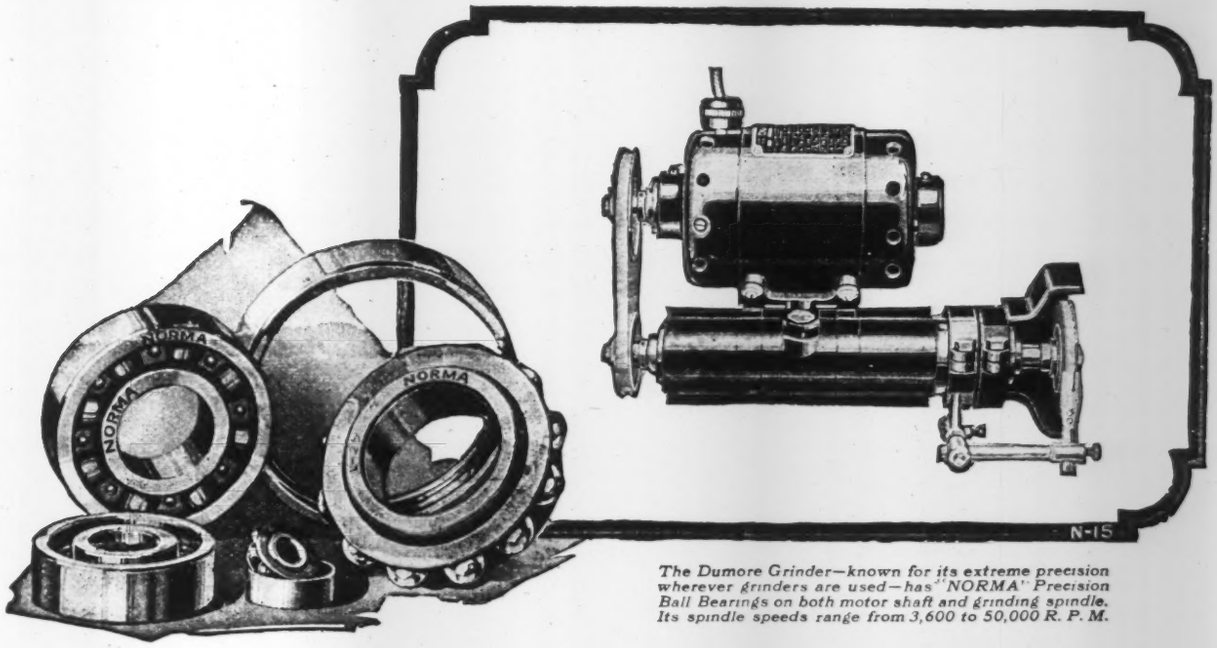

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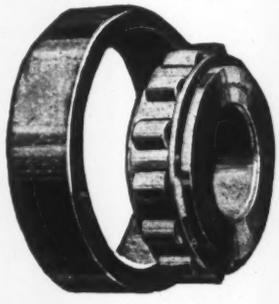

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giving at least twice the load capacity of any ball bearing without increase in dimensiosn or sacrifice of speed-ability.

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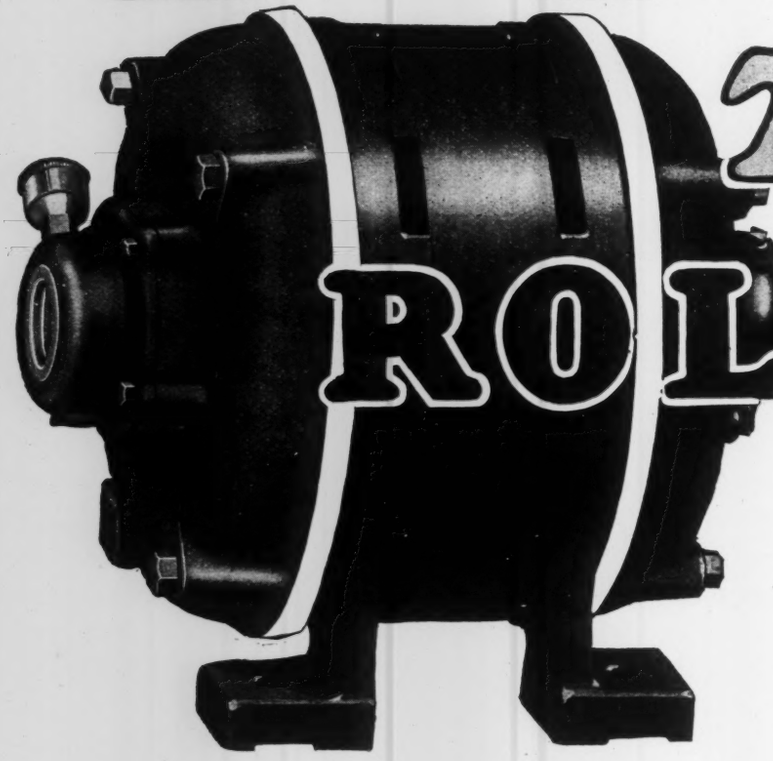

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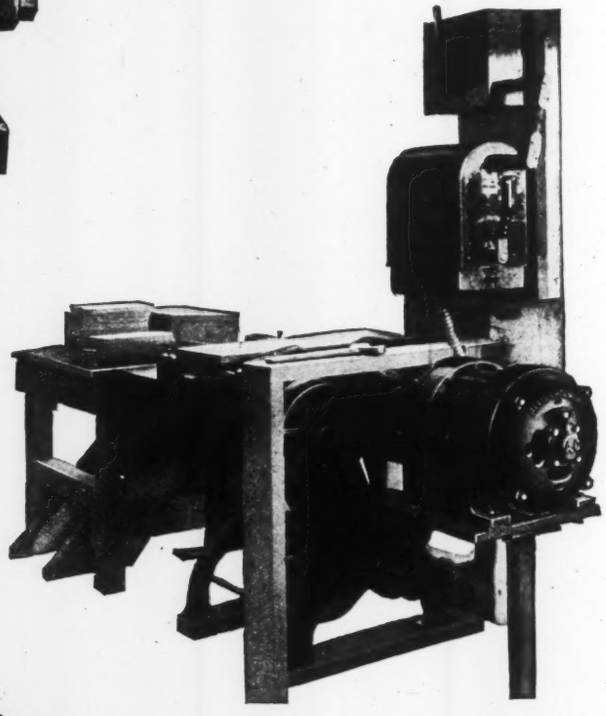
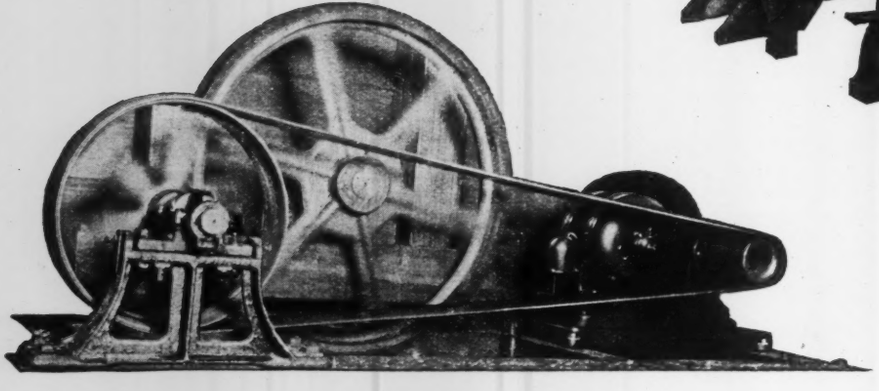
ROLLER





TIMKEN

-tapered

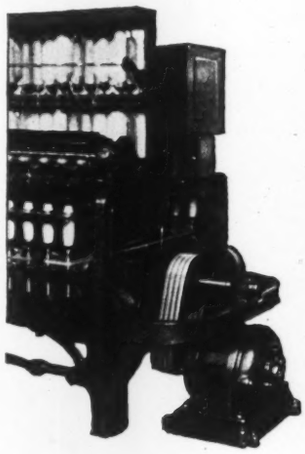
BEARINGS

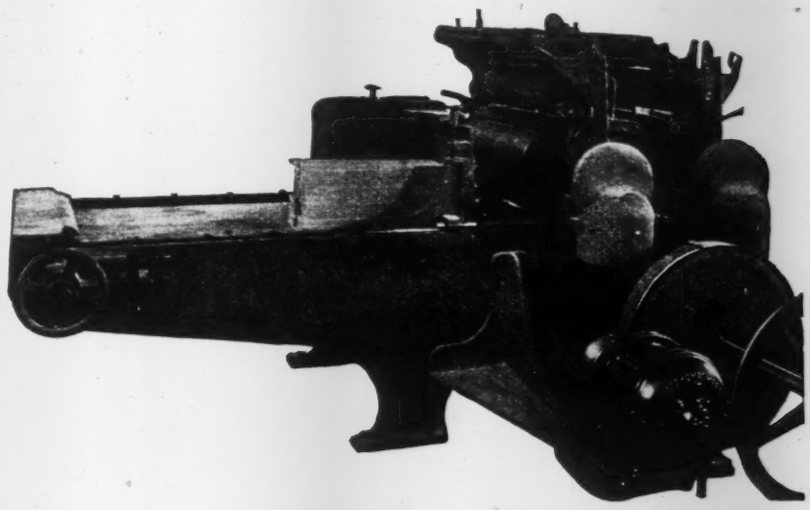
THERE are certain electric motor tasks where *any* bearings serve reasonably well. Here Timken Bearings add the value of anti-friction properties—saving power—eliminating all but one or two greasings a year—improving starting conditions—*maintaining the closest gap permanently*.

But there is many an electric motor task where *no* bearings served satisfactorily until the job was awarded to Timkens. For only Timken Bearings provide the extreme load capacity of Timken Tapered design and Timken-made electric steel, with positively aligned rolls.

Inherently higher resistance to thrust, shock, and every other form of wear is what Timkens give you, over and above anti-friction advantages. It is extra worth at no extra cost, because Timken-equipped motors, simple, compact and highly reputed, are more economically operated.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO





Thrust load capacity up to 50% of radial load capacity

NOMINAL COST PLUS BETTER SERVICE

THE outstanding features of "COMMERCIAL" Annular Ball Bearings are low cost and high efficiency. That is why the demand for these bearings increases and expands year by year. They are adaptable to hundreds of different products and various types of duty. Accurately built and carefully finished. Use "COMMERCIALS" in your product or plant.

Commercial
ANNULAR BALL BEARINGS

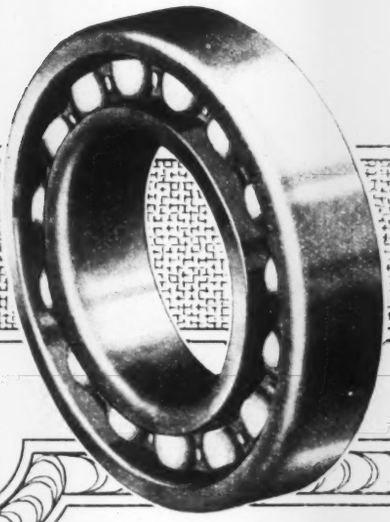
A TYPICAL INSTALLATION

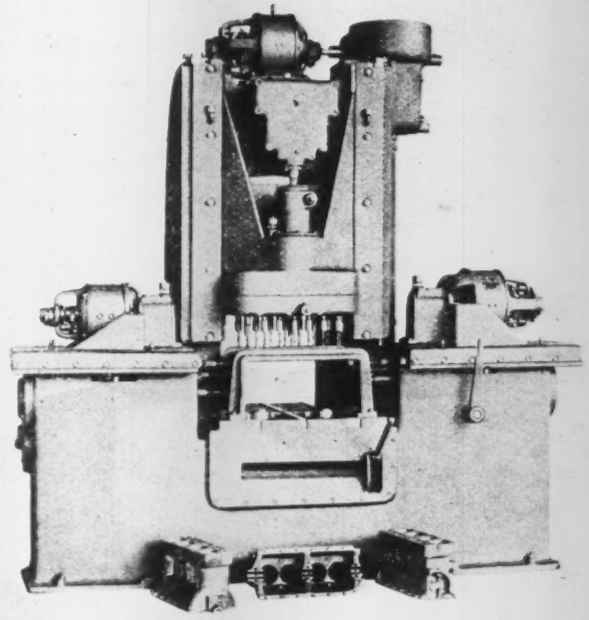
This type AHR "COMMERCIAL" Annular Ball Bearing—CS-611x1—is used on elevator doors. The threaded bore is a feature which can be furnished on any "COMMERCIAL" Annular Ball Bearing or Roller. In some cases it greatly reduces assembly costs.

Send for Illustrated Catalog, Discount Sheets and Samples.

THE SCHATZ MANUFACTURING CO.

Poughkeepsie **New York**





New Departure Quality Ball Bearings

21 Bull's-eyes Every Time

21 drill spindles are each permanently and accurately located by New Departure Ball Bearings, permitting quantity production with absolute interchangeability of product. This is a task not possible day-in and day-out with sleeve bearings or anti-friction types which wear to an extent necessitating re-adjustment at intervals.

Furthermore, New Departure Ball Bearings maintain alignment of shafts and accurate meshing of gear trains in the transmission of power from motors to spindles with friction losses reduced to a minimum.

"Ball Bearing Application" is the title of a unique engineering reference book, invaluable to engineers and designers who would improve their plant or product. New loose leaf sheets added monthly. Furnished free to those in a position to use it to advantage.

The New Departure Manufacturing Company
Detroit Bristol, Connecticut Chicago

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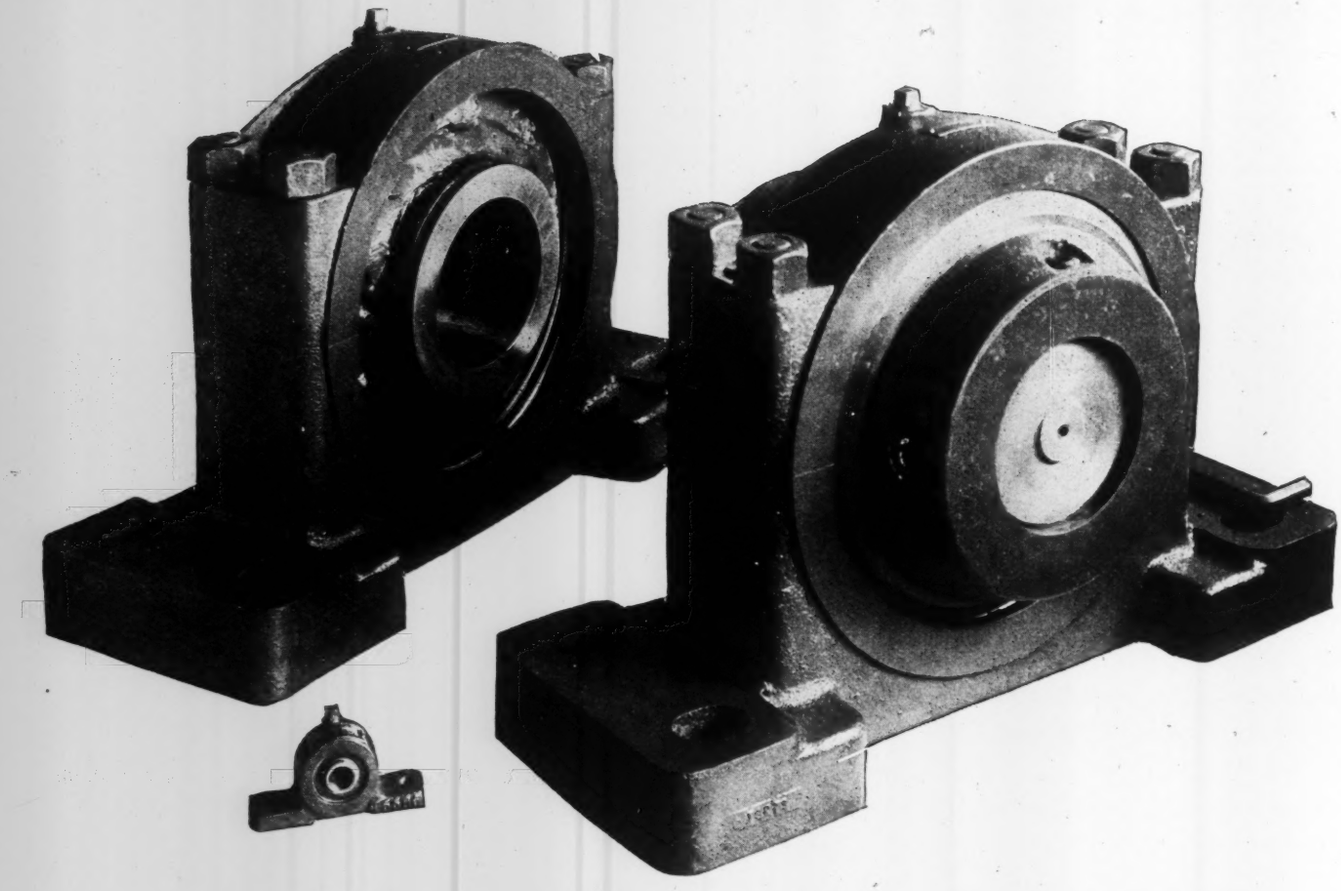

From the *smallest* to the *largest!*

NOTE the tiny $\frac{11}{16}$ inch Fafnir Single Ball Bearing Self-aligning Pillow Block. Also the two huge blocks, of 5-$\frac{15}{16}$ inch size.

A remarkable contrast! Yet it indicates the wide range of sizes and load-carrying capacities in which Fafnir Ball Bearings are supplied. You can get Fafnirs for light service. For heavy service. For almost every kind of installation and type of machine. But in each bearing you get Fafnir quality and Fafnir advantages—molybdenum steel, deep groove raceways, and the maximum number of largest diameter balls. And this means unfailing bearing operation in every service.

THE FAFNIR BEARING COMPANY, NEW BRITAIN, CONN.

Makers of high grade ball bearings—the most complete line of types and sizes in America

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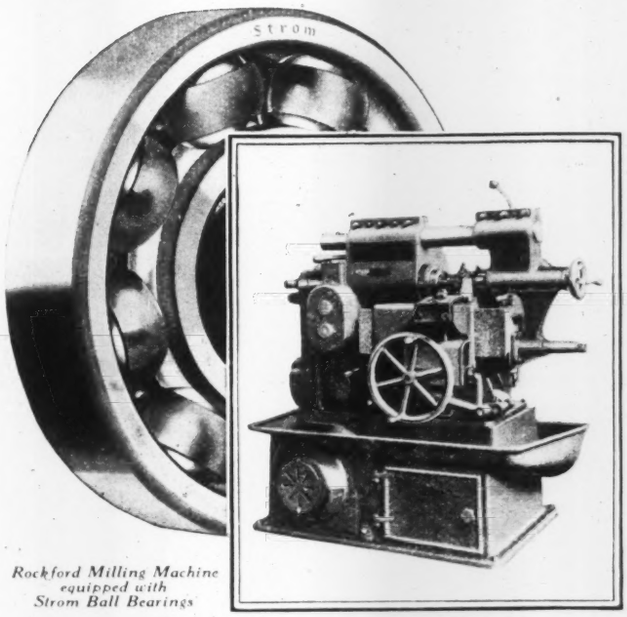
FAFNIR

BALL BEARING
UNIT-ALIGNING
TRANSMISSION EQUIPMENT

THE MOST COMPLETE LINE OF TYPES AND SIZES IN AMERICA



Rockford Milling Machine equipped with Strom Ball Bearings

Defying the "shock loads"

Because of Strom demonstrated ability to withstand unusual shocks and strains—to retain accuracy under the severe "shock loads" to which bearings in a lathe are subjected—Strom Ball Bearings are standard equipment on the machine illustrated above.

Under severest conditions, these sturdy, accurate bearings insure the required rigidity in the rotating units, and at the same time reduce friction losses and vibration to the minimum.

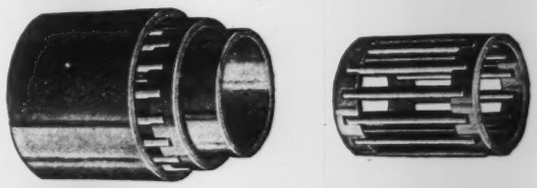
Strom precision and durability also assure longer life of the machine, greatly reducing the expense for repairs and adjustments. Moreover, Strom Ball Bearings save time and labor in oiling, for they need less oil.

Thousands of manufacturers today are proving that machinery equipped with Strom Ball Bearings cuts down operating expense and speeds up production. Let us send you catalog and complete technical data.

Strom BALL BEARINGS

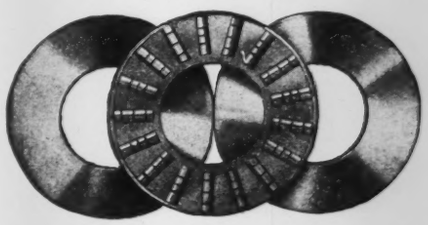
Strom Bearings Co.
4540 Palmer Street, Chicago, Ill.

ROLLER BEARINGS



JOURNAL ROLLER BEARINGS

With or Without Casings or Sleeves



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STANDARD SIZES OR TO ORDER

Any quantity—one bearing or one thousand

THE GWILLIAM COMPANY

23 Flatbush Avenue, BROOKLYN, N. Y.

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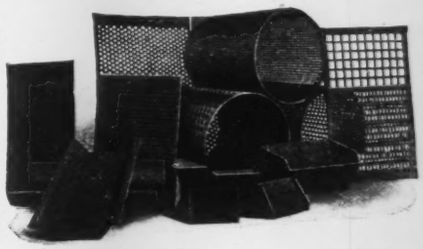

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Elevator Bucket (plain or perforated)
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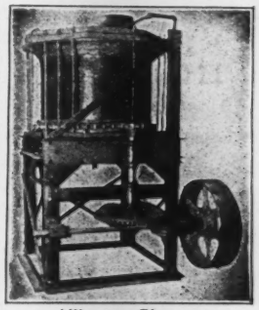

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50,000 lbs. per hour or less.
Distances 4,000 ft. or less.
Free from danger of clogging.
Saves power. Automatic.

If you have a problem of any kind concerning a gathering or conveying fan, we can help you. That has been our business since 1888.

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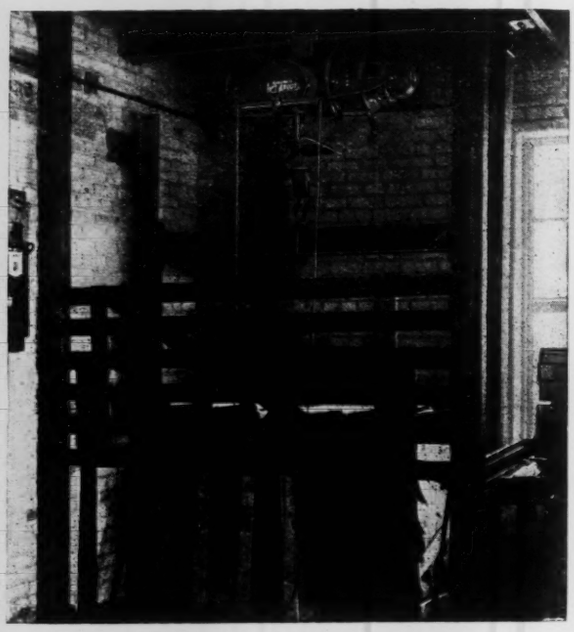
565 Washington Blvd., Chicago, Ill.
Rm. 451, No. 50 Church St., New York.

Originators of Slow-speed, Low-power methods for collecting sawdust, shavings, etc.



Handling time cut 87½%

A simple application of a Shepard Electric LiftAbout to lift and lower a platform elevator made this big saving for the Consumers Power Co., Pontiac, Mich.

This is one example of LiftAbout versatility. There are numerous others, so many that this sturdy little machine has proved to be "An Electric Hoist for Everybody."

It is made in ¼, ½ and 1 ton capacities. There are many types to "fit" many plant conditions. The price is low, because standardization and quantity production cut our manufacturing costs.

Thousands and thousands of these LiftAbouts are in use—each doing a job at a cost very much lower than manual labor or improvised methods.

The LiftAbout will save for you, too.

Ask for the "Book of Illustrated Economies."

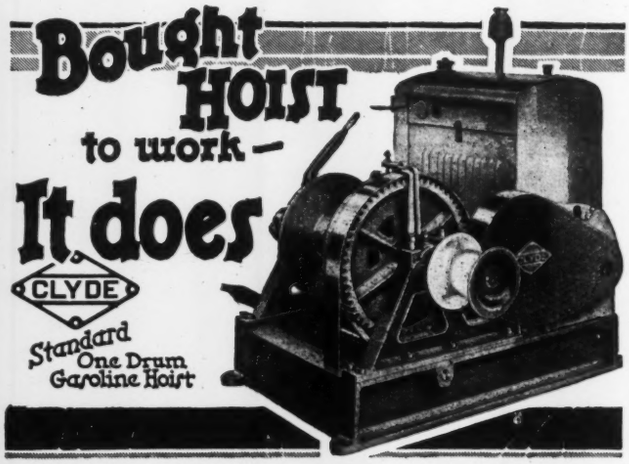
SHEPARD ELECTRIC CRANE & HOIST CO.
370 Schuyler Ave., Montour Falls, N. Y.

Branches in Principal Cities

Largest Manufacturer of Electric Hoists in America

SHEPARD
ELECTRIC CRANES & HOISTS

Bought HOIST to work— It does



"Our Clyde Gasoline Hoist runs as silently as a kitten. The automatic governor is great and we can throttle the motor down so it sounds like a Packard. Gentlemen, we bought that hoist to work, and believe me, it does. It's Some Hoist!"
ANTONE & RANSOM, Greenfield, Mass.

Clyde Hoists are made in steam, gasoline and electric motive power, one to three drums, four to one-hundred horse power. Complete information on request about the particular hoist you need.

You'll Take Pride in Your Clyde!

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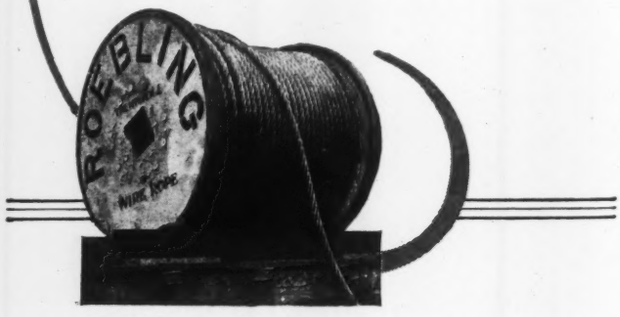


Upper Run of V-Bucket Conveyor over coal bunker.

Ralston Steel Car Company *again selects Jeffrey Equipment*

SEVEN years ago, the Ralston Steel Car Company of Columbus, Ohio, one of America's leading manufacturers of Freight Car Equipment, installed a Jeffrey Coal and Ashes Handling Equipment in their boiler house.

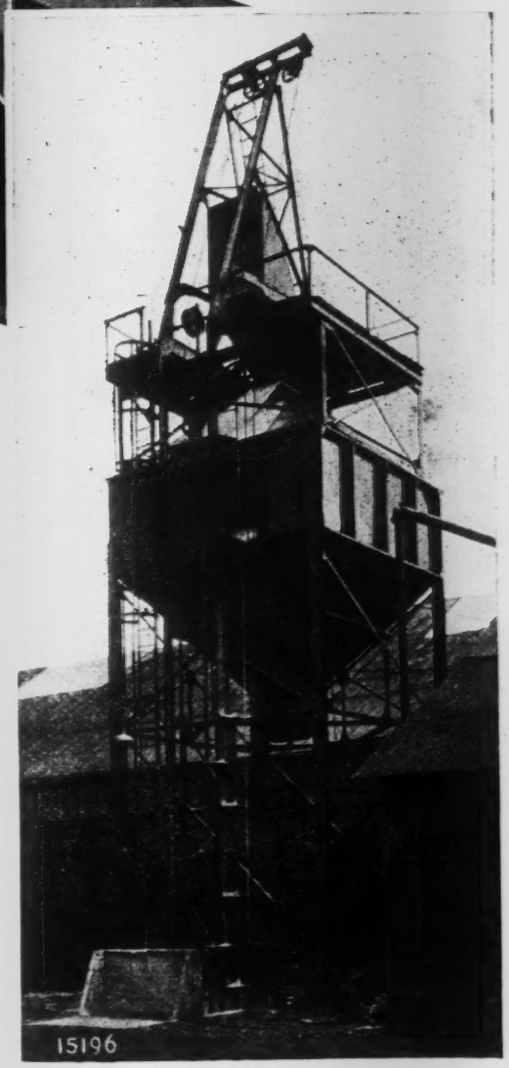
Seven years of progress and growth made it necessary to enlarge their power plant equipment to keep pace with increasing production.

The original installation having proved so satisfactory, it was only natural that in the selection of new coal and ash handling equipment, the Ralston Company again looked to Jeffrey Service.

Practically the same type of equipment was specified for the larger requirements—and, in fact, much of the old equipment was still in such excellent condition that it could be worked into the new design. All the buckets on the original V-Bucket Conveyor were used on the new conveyor of similar type.

The extension also included a new Jeffrey Plate Feeder, Single Roll Crusher, and Skip Hoist with Ash Bin shown at the right.

Motion pictures of typical Jeffrey coal and ashes handling installations will be shown in Booth 743 at the New York Power Show, December 6 to 11. Jeffrey representatives will be there to answer your questions concerning coal and ashes handling.



Jeffrey automatic Skip Hoist and Ash Bin

The Jeffrey Manufacturing Company

915-99 North Fourth Street, Columbus, Ohio

New York	Scranton, Pa.	Chicago	Salt Lake City
Buffalo	Boston	Detroit	Los Angeles
Rochester, N. Y.	Cincinnati	Milwaukee	Birmingham
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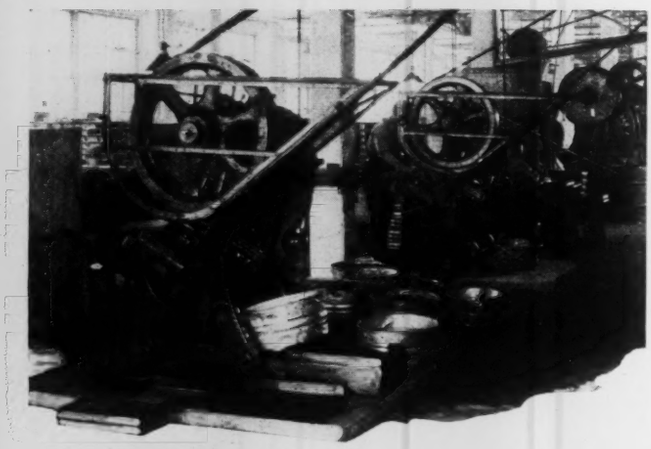
JEFFREY
MATERIAL HANDLING EQUIPMENT

Jeffrey Products

- Elevators—Conveyors
- Portable Loaders
- Coal and Ashes Handling Equipment
- Skip Hoists
- Chains and Attachments
- Sprocket Wheels—Gears
- Crushers—Pulverizers
- Sand and Gravel Handling, Washing, and Screening Equipment
- Locomotives
- Coal Mine Equipment
- Tipple Equipment
- Ventilation Fans

Locks
in huge volume



A successful manufacturer in the highly competitive lock-making industry saves cost by combining on a battery of inclinable Niagara presses the operations of

Blanking
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Tell us what you make—or wish to—from sheet metal and we will show you machines to make the parts at a cost to meet and beat competition.

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Hartness Flat Turret Lathe
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JONES & LAMSON MACHINE COMPANY
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Tolhurst Chip Wringers reclaim 6 to 15 gallons per load and handle three or four loads an hour!
TOLHURST MACHINE WORKS, TROY, N. Y.

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Engineers and inventors who desire mechanical development of ideas will find our service indispensable.

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New Production Saw for High Speed Metal Cutting

Racine Shear-Cut—operates on a new principle.

A remarkable addition to the Racine Complete Line. Makes clean accurate cuts *in one-half to one-third the time of ordinary machines.* Time per cut does not vary. Triples life of saw blades. Greater speed—greater accuracy—more economy. Most important improvement of 15 years in metal cutting machinery.

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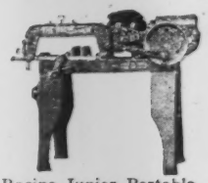
Machines of every capacity—for every cutting purpose. Direct drive from motor either with Link Belt Silent Chain or with worm gear. Write for bulletins. Send for Free Chart "The Right Saw for the Purpose."

Racine Tool & Machine Co. (Dept. M), Racine, Wis.



Racine Junior Portable. Runs from electric light or power circuit. Capacity 4".

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It comprises 150,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 1,300 technical journals and magazines are regularly received, including practically every important engineering journal in the civil, mechanical, electrical, and mining fields.

The Library is open from 9 a. m. to 10 p. m. with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

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They Stay Set

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We specialize in the manufacture of sheet metal parts from the simple to the most intricate design.

We are equipped to make these parts quickly, accurately and economically.

In many instances former users of Iron Castings have found

SHEET METAL PARTS

more practical, and saving much time and expense.

Have your next parts made of sheet metal—send us a blue print or pencil sketch and we will show you how to reduce your present costs.

STEEL, IRON, BRASS, COPPER, MONEL METALS—TAMPING, FORMING, DRAWING, BLANKING, PUNCHING

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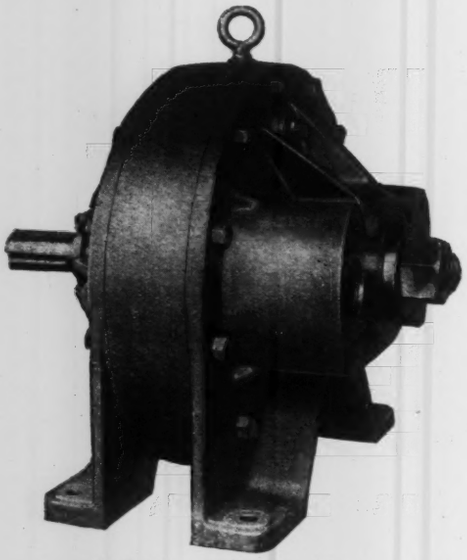
CINCINNATI, OHIO



Hele-Shaw Hydraulic Motor

Hydraulic Motors For Rotary Drives

The Hele-Shaw Hydraulic Motor, used in conjunction with the Hele-Shaw Hydraulic Pump, makes it possible to apply hydraulic power directly to rotary drives.

Wherever flexibility, smooth action, ease and accuracy of control, combined with high mechanical efficiency and simplicity of design, are important, the Hele-Shaw drive requires consideration.

This combination of Hele-Shaw Hydraulic Pump and Motor provides practically unlimited power for peak loads or unusual resistances because simple controls make it possible to regulate the discharge from the pump, and consequently the speed of the motor, without changing the speed of the electric motor that drives it. This eliminates the need for complicated electrical controls.

Send for catalog today.

American Fluid Motors Company

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Hele-Shaw Hydraulic Pump

ALLEN PROCESS SOCKETS

LOOK FOR THE CORNER TRIANGLES

TRADE MARK

You have two ways to pay for your hollow screws:—pay as you go or pay as the *set screws* go.

—Pay your Jobber for cold-drawn "ALLENS" or pay your mechanic for picking out the remains of *weaker* screws, broken in service.

There might be a penny's difference in price between a cold-drawn ALLEN and an ordinary broached screw. But for that same broached screw *broken down,* add 60c for mechanic's time. Add dollars for lost production-time.

We think you'd rather pay as you go than pay as your set screws go. So we make you a 30 percent stronger screw, and a hundred percent satisfied user if you'll let us.

THE ALLEN MFG. CO.

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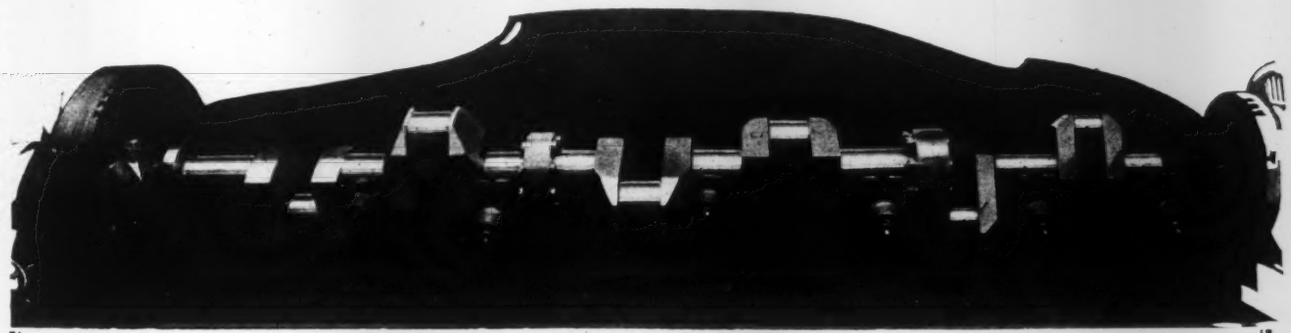

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The illustration above shows a forged steel crankshaft recently delivered to this country by SKODAWORKS for use in a Diesel Engine. Crankshafts, Rotor Spindles, Forged Pressure Drums, Tires, etc.—which must withstand unusual strain and for which the highest quality of material and workmanship is essential—are manufactured by SKODAWORKS and delivered to any part of the United States with a decided saving in time and money. This applies also to steel castings, and is particularly true for finished steel parts and when the job is of exceptional size or of an unusually difficult nature.

We are proud of the high repute of our American customers who expressed satisfaction with quality and delivery which they experienced in ordering from SKODA.

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Open Hearth and Alloy Steel

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WELDLESS RINGS GEAR BLANKS SPINDLES

Smooth Forged or Rough Machined

Special Facilities for

HEAT TREATING

FORGED STEEL **PIPE FLANGES**

IN THE ROUGH HYDRAULIC EXPANDED VAN STONE FINISH-MACHINED REDUCING **FLANGES** BLIND SPECIAL RING GASKET STANDARD NEW ADOLSO WELDING SCARF

PLANT ROYERSFORD, PA. MAIN OFFICE PHILADELPHIA, PA.

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ARE YOU SATISFIED?

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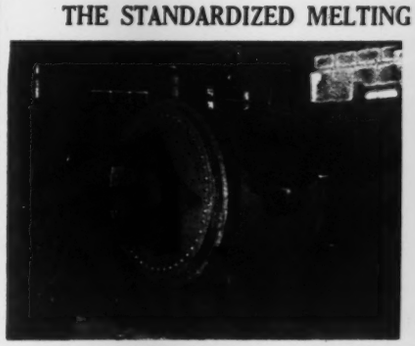
THE STANDARDIZED MELTING MACHINES



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BRONZE
COPPER
ALUMINUM
GREY IRON

Detroit Electric Furnace Co.
2231 Park Ave., Detroit.

Alloy Steels Speed the World's Progress

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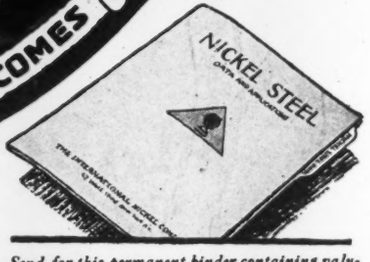
Because flawless mechanisms turn and spin on tracks or highways — delivering power when and as wanted—travelers arrive on time and as promptly depart. Alloy Steels have made dependable transportation a reality.

For stress members and moving parts of vehicles of every kind, engineers have recommended various types of Alloy Steel. To meet the need for a material that is strong but light, tough but elastic, adaptable to the many different requirements, these metallurgists have chosen Alloy Steel. With from 25% to 100% greater loading capacity than carbon steels, and with more hardness and strength per unit of cross-section, Alloy Steels have a shock resistance that is remarkable. They endure where other metals fail.

Alloy Steels are necessary to the engineering plans of industry, everywhere. They will fit into YOUR plans. Why not let our engineers tell you how and where Alloy Steel can help in the solution of your metal problems. Our laboratory facilities are at your disposal.

In the famous Mack trucks made by The International Motor Company of New York, Nickel-bearing Steels have been used for such vital parts as: frames; axles; steering knuckles, arms, pins, worms, and gears; spring clips; cam shafts, and rollers; transmission, differential, and double reduction gears; jack shafts, and rear axle drive shafts.

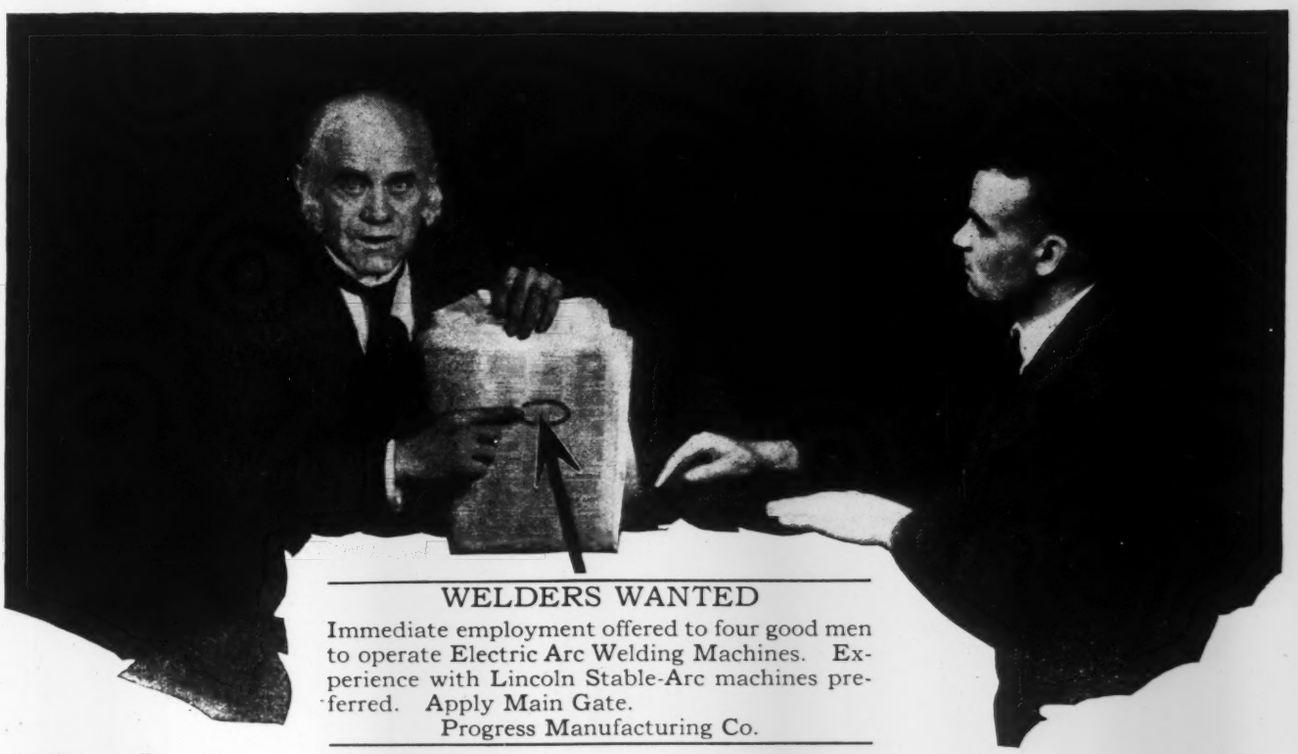


Send for this permanent binder containing valuable data on Nickel Steels—their properties and applications. Mention this magazine in writing.

ALLOY STEEL

THE INTERNATIONAL NICKEL COMPANY, 67 WALL STREET, NEW YORK CITY.
Producers of INCO Nickel in all commercial forms

Pop finds Real News in the Newspaper



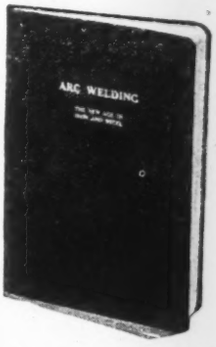
WELDERS WANTED

Immediate employment offered to four good men to operate Electric Arc Welding Machines. Experience with Lincoln Stable-Arc machines preferred. Apply Main Gate.

Progress Manufacturing Co.

"See Lad—

here's an ad by our sweet competitor across the way wanting four men for electric welders—what does it mean—what are they UP TO, anyway?"



This new text book on Arc Welding (Price $1.50) will be sent on approval for five days to any executive requesting it.

Book size, 6"x9"—Total pages, 160—Number illustrations, 200—Charts, 62—Divisions, 18.

"I'll tell you, Pop—

they're up to the minute because they're going to use steel in place of cast iron and it *means* these things in the order named:

(1) They're going to raise the quality of the machine WE have to compete with.

(2) They're going to raise the production speed.

(3) They're going to raise hob with our sales because the raise in quality and quantity is accomplished by a drop in cost.

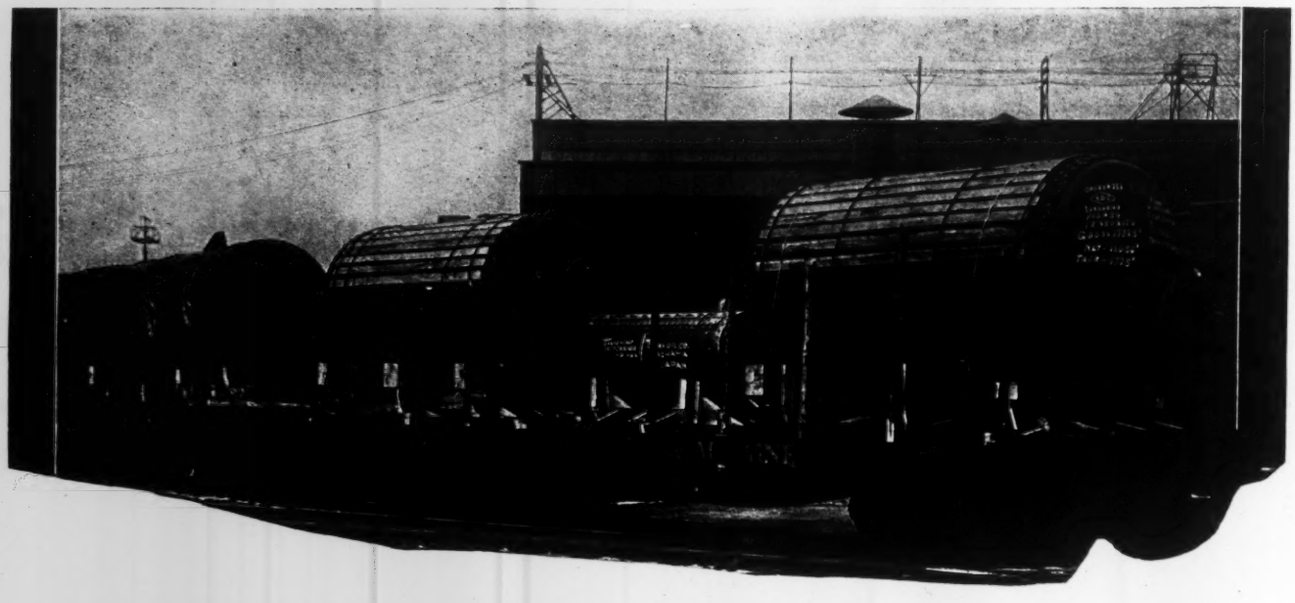
And your cue is to get the whole story on this new manufacturing process—then run a similar want ad in the paper."

Better get in touch with Dept. No. 24–12.

The Lincoln Electric Co., Cleveland, Ohio WC-2

LINCOLN "Stable Arc" WELDER

Steel Plate Equipment



Industrial plants, the country over, require quite a considerable amount of equipment built of steel plate. This equipment varies from ordinary steel tanks to very special construction as breechings—flues—mixers—etc.

But no matter what the equipment, you will find much that is Graver built. For in the 69 years of Graver's experience there is scarcely any steel plate equipment for an industrial plant which Graver has not fabricated.

Graver facilities and experience are at your disposal for the building of your steel plate equipment.

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Tanks
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Riveted
RIOW [*Riveted, Inside & Outside Welded*]
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Any Size Tanks Erected Anywhere
Elevated Tanks
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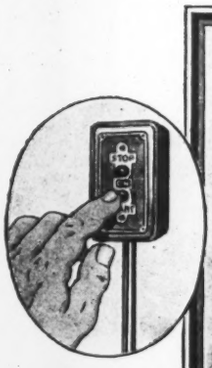
GRAVER *Founded 1857* Corporation

EAST CHICAGO, INDIANA

NEW YORK CITY CHICAGO TULSA, OKLA.



The trend of industry is decidedly toward Cutler-Hammer Push Button Control. Merely a touch of the proper button right at the machine starts, accelerates, decelerates, regulates the speed or stops the motor as required. The controller is placed in any safe, convenient location. Saves time, affords better control and provides greater safety—a logical step in advance.

This booklet "Industry's Electrical Progress" puts into concise, interesting form the story of savings through modern motor control. Write for your copy today.

Motors by themselves are only brute force

The economies that electric power brings to industry depend on correct motor control

IT seems so simple—and yet in so many plants this basic truth is often neglected.

Motors by themselves are only brute force!

Engrave it on the minds of the men who design *your* equipment. Burn it into the memory of those who specify—those who buy. For today it is the battle cry in the fight to reduce manufacturing costs!

Every motor you put into service offers the opportunity of minimum operating expense. It can save in power costs. It can speed up production. It can save in labor—that major item of manufacturing burden. But you are trifling with opportunity if you leave these possible economies to chance—these economics that result not from the mere installation of motors, but from the production efficiency you are able to obtain through the perfect control of their brute force.

Competitive conditions today demand the accurate powering of equipment. Plan your drives considering the work to be done. That means the choice of motor control equipment first—choice of the type of control equipment that affords maximum speed of production—that ties in closest with the manual operations involved. The proper type of motor can *then* be selected to give maximum results.

Carry this story to the men of your plant! Have them check the motors you have in service. Like many other plants, you will find that modern motor control on many existing drives will pay for itself in a few months—and then add steadily to profits.

If you desire, Cutler-Hammer field engineers will gladly counsel with your plant men or consulting engineers to determine where savings may be obtained—to show them the latest control equipment available for every need. Their recommendations are based on more than thirty years' experience. This service is also offered for the planning of new drives, and their co-operation does not place you under any expense or obligation.

The CUTLER-HAMMER Mfg. Co.

Pioneer Manufacturers of Electric Control Apparatus

1216 St. Paul Avenue Milwaukee, Wis.

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J-3052 Cushioned Starting Saves Belts and Bearings

THE severe jerks and strains of starting, with either a hand or automatic compensator, destroy belts and bearings. That is why Allen-Bradley J-3052 Automatic Starters prove so economical.

The use of Bradleyunit Resistors (graphite disc compression resistances) make it easy to steplessly adjust the starting torque by merely turning a single screw to start the machine without a jerk, and gradually accelerate it to full speed. The timing relay automatically switches the motor from starting to running voltage, without opening the motor circuit.

The most unskilled operator can make a perfect start with the J-3052. He simply pushes a button—the starter does the rest.

Allen-Bradley Automatic Compression Resistance Starters are adding to the life of motors, belts and machinery in all types of industrial plants. They cost less than automatic compensators. *Investigate—Mail the coupon today!*

Allen-Bradley Company, 490 Clinton St., Milwaukee, Wisconsin

If your starters can reduce our operating costs and increase production, we want to know about them. Mail your catalog today.

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Address.....

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Engineers who use Dixon's Flake Graphite regularly as a lubricant do not worry about hot boxes or scored cylinders. They know that their machines are giving better and more economical service than if lubricated with oil alone.

Dixon's Flake Graphite reduces the friction in steam cylinders and valves to the minimum and thus lengthens the life of packing rings, prevents scoring, reduces blowing, eliminates oil from the exhaust, and saves coal.

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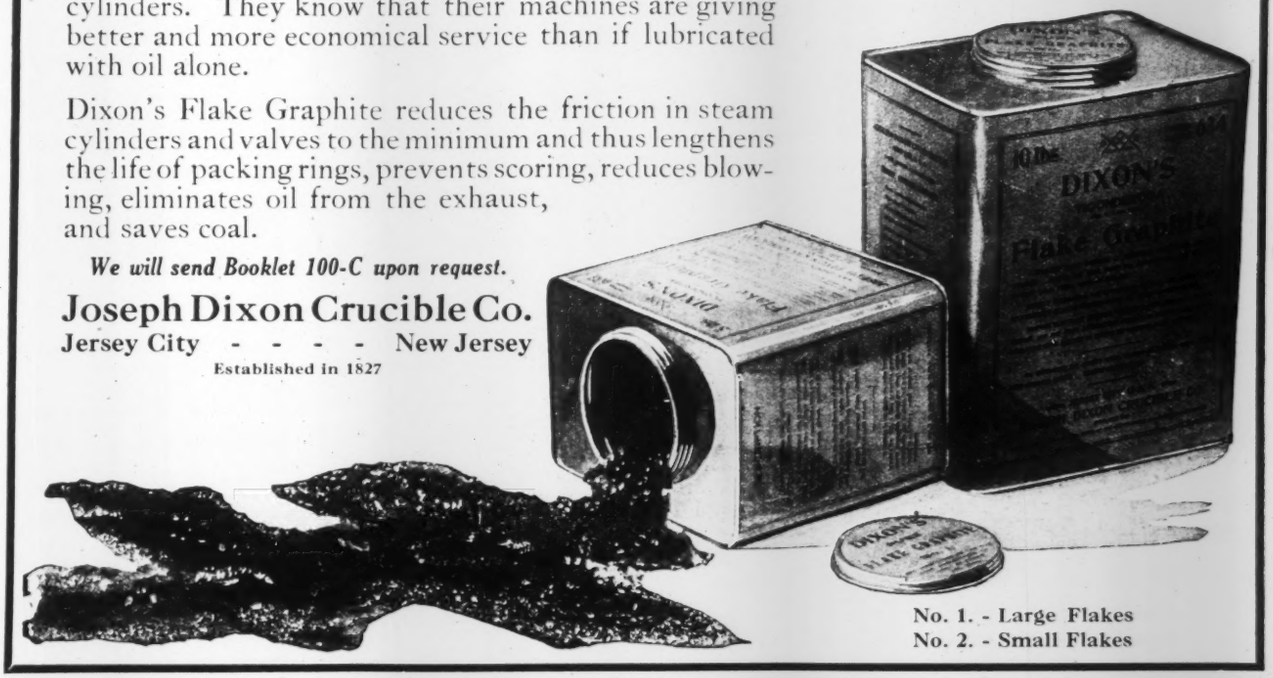
Joseph Dixon Crucible Co.
Jersey City - - - - New Jersey
Established in 1827



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LONG ISLAND CITY, N.Y. U.S.A.
Established 1902

P-119

You'll Feel at Home at this Drawing Table

Adjust the board of this Sphinx Drawing Table to the angle that suits you best—prop your feet on the comfortable foot rest—pencils, pens and ink right at your elbow—then notice how much easier drawing will seem.

The Sphinx Adjustable Drawing Table stands firm on its ashwood trestles. The easily adjusted board is made of selected white basswood. A box as long as the table holds all your drawing instruments when you are not using them. Careful, sturdy construction is evident throughout.

Pick your drawing table with as much care as you would exercise in buying drawing instruments. Choose WEBER'S in both cases.

WEBER-SPHINX, Drawing Instruments for the student.

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Old fashioned blueprint
Clean, clear OZALID Red Line Print

At Last! A Workable, Finished Print

which is a positive print, made direct from the tracing without negatives—a dark maroon line on a light cream background—clear, legible, attractive.

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Prints are clear, legible, true to scale, non-fading and durable. May be written or drawn upon with pen, pencil, crayon or water colors, and may be used as originals.

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Write for sample OZALID print and our booklet describing this amazing new process which produces admirable, finished prints with surprising economy.

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The work done by these tiny, mighty little seals has helped to cut the tuberculosis death rate by more than half.

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A Super-Vellum

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Drawers are equipped with patent Geimer hold-down irons to prevent curling of tracings.

Sturdily constructed of re-annealed, cold-rolled furniture steel, "Pease" cabinets cannot sag, while welded corners insure perfect joints. The rich, olive-green, baked enamel finish, carefully applied in successive coats, will retain its lustre indefinitely.

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842 N. Franklin St., Chicago, Ill.

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LET BLUE PRINTS TELL YOUR STORY

Makes fine lines for

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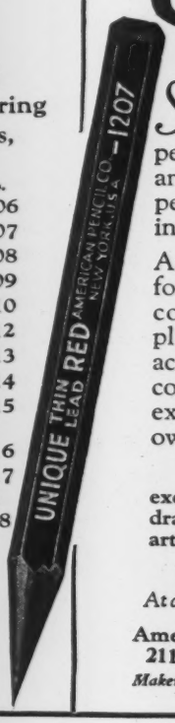

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An absolute necessity for making fine lines in color on charts and plans—something never achieved before. The 12 colors also enable each executive to have his own color symbol.

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executives • accountants
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Makers of the famous Venus Pencils

Professional Engineering Service

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JAMES W. COX, Jr.
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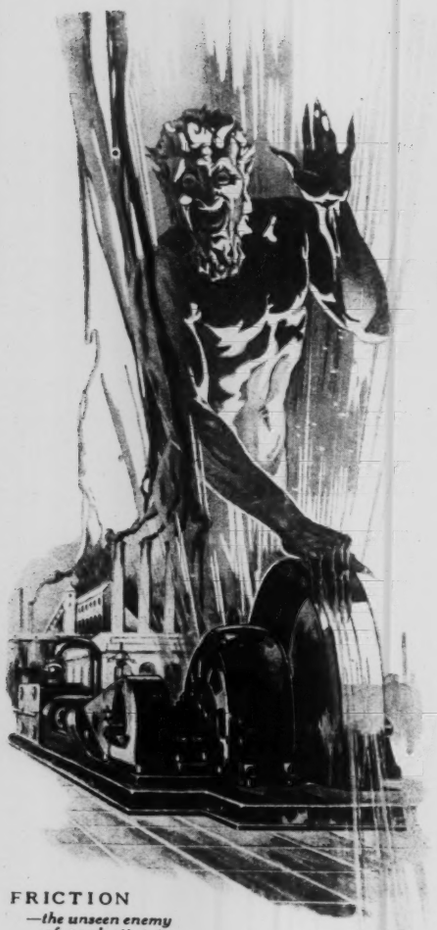

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International Pattern Corp'n
* Murray, D. J. Mfg. Co.
Walworth Co.

Castings, Bronze
* Bethlehem Steel Co.
* Economy Pumping Machinery Co.
* d'Este, Julian Co.
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Castings, Copper
* d'Este, Julian Co.

Castings, Die-Molded
Veeder Mfg. Co.

Castings, Heavy
* Bethlehem Steel Co.
* Erie City Iron Works
* Farrel Foundry & Machine Co.
* Fuller-Lehigh Co.
Hill Clutch Mach. & Fdry. Co.
* Murray, D. J. Mfg. Co.
Skodaworks (Arthur J. Herschmann)
* U. S. Cast Iron Pipe & Fdry. Co.

Castings, Iron
* Bethlehem Steel Co.
Brown, A. & F. Co.
* Builders Iron Foundry
* Burhorn, Edwin Co.
* Casey-Hedges Co.
* Chain Belt Co.
* Cole, R. D. Mfg. Co.
* Croll-Reynolds Engineering Co.
* Economy Pumping Machinery Co.
* Erie City Iron Works
* Falls Clutch & Machinery Co.
* Farrel Foundry & Machine Co.
* Franklin Machine Co.
* Fuller-Lehigh Co.
* Garlock Packing Co.
* Graver Corp'n
Harrisburg Fdry. & Mach. Wks.
Hill Clutch Mach. & Fdry. Co.
International Pattern Corp'n
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Murray, D. J. Mfg. Co.
* Nordberg Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co.
Skodaworks (Arthur J. Herschmann)
Struthers-Wells Co.
* U. S. Cast Iron Pipe & Fdry. Co.
* Vogt, Henry Machine Co.

Castings, Monel Metal
* International Nickel Co.

Castings, Nickel
* International Nickel Co.

Castings, Semi-Steel
* Builders Iron Foundry
* Chain Belt Co.
* Croll-Reynolds Engineering Co.
* Erie City Iron Works
* Farrel Foundry & Machine Co.
Hill Clutch Mach. & Fdry. Co.
* Murray, D. J. Mfg. Co.
* Nordberg Mfg. Co.
Struthers-Wells Co.
* Vogt, Henry Machine Co.
Walworth Co.

Castings, Steel
* Bethlehem Steel Co.
* Falk Corporation
* Reading Steel Casting Co. (Inc.)
Skodaworks (Arthur J. Herschmann)
Walworth Co.

Castings, White Metal
* d'Este, Julian Co.

Cement, Asbestos
Carey, Philip Co.
Walworth Co.

Cement, Iron and Steel
Smooth-On Mfg. Co.

Cement, Pipe Joint
Smooth-On Mfg. Co.

Cement, Refractory
* Celite Products Co.
Johns-Manville (Inc.)
King Refractories Co. (Inc.)
* McLeod & Henry Co.
* Quigley Furnace Specialties Co.

Cement, Water-Resistant
Smooth-On Mfg. Co.

Cement Machinery
* Allis-Chalmers Mfg. Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Smidth, F. L. & Co.

Centrifugals, Chemical
Tolhurst Machine Works

Centrifugals, Metal Drying
Tolhurst Machine Works

Centrifugals, Sugar
Tolhurst Machine Works

Chain Belts and Links
* Chain Belt Co.
* Diamond Chain & Mfg. Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Morse Chain Co.
* Murray, D. J. Mfg. Co.
* Whitney Mfg. Co.

Chains, Power Transmission
Baldwin Chain & Mfg. Co.
* Chain Belt Co.
* Diamond Chain & Mfg. Co.
* Jeffrey Mfg. Co.
* Morse Chain Co.
* Murray, D. J. Mfg. Co.
* Philadelphia Gear Works
* Whitney Mfg. Co.

Chimneys, Brick (Radial)
Kellogg, M. W. Co.

Chucking Machines
* Jones & Lamson Machine Co.
Warner & Swasey Co.

Chucks, Drill
* Whitney Mfg. Co.

Chucks, Magnetic
* General Electric Co.

Chucks, Tapping
* Whitney Mfg. Co.

Chutes
* Breese Bros. Co.
* Chain Belt Co.
* Hendrick Mfg. Co.
* Jeffrey Mfg. Co.
* Murray, D. J. Mfg. Co.

Circuit Breakers
American Brown Boveri Elec. Corp'n
* General Electric Co.

Circulators, Feed Water
* Schutte & Koerting Co.

Circulators, Steam Heating
* Schutte & Koerting Co.

Clamps, Pipe and Pipe-Joint
Walworth Co.
* Yarnall-Waring Company

Clarifiers
* Hardinge Co.

Clocks, Engine Room
* American Schaeffer & Budenberg Corp'n

Cloth, Rubber
* Garlock Packing Co.

Cloth, Tracing
Alteneder, Theo. & Sons
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)

Clutches, Friction
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
* Falls Clutch & Machinery Co.
* Farrel Foundry & Machine Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
Johnson, Carlyle Machine Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
* Philadelphia Gear Works
* Western Engineering & Mfg. Co.
Wood's, T. B. Sons Co.

Clutches, Magnetic
Cutler-Hammer Mfg. Co.

Coal and Ash Handling Machinery
* Chain Belt Co.
* Combustion Engineering Corp'n
* Jeffrey Mfg. Co.
* Palmer-Bee Co.
Shepard Electric Crane & Hoist Co.

Coal Bins
* Chain Belt Co.
* Erie City Iron Works
* Jeffrey Mfg. Co.

Coal Breakers and Cleaners
* Pennsylvania Crusher Co.

Coal Mine Equipment and Supplies
* General Electric Co.
* Jeffrey Mfg. Co.

Coal Mining Machinery
* General Electric Co.
* Ingersoll-Rand Co.
* Jeffrey Mfg. Co.

Coal Tipples
* Fairbanks, Morse & Co.
* Jeffrey Mfg. Co.

Coal Washers
* Hardinge Co.

Coaling Stations, Locomotive
* Chain Belt Co.

Coatings, Metal Protecting
* American Machine & Fdry. Co.
Struthers-Wells Co.

Cocks, Air and Gage
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Jenkins Bros.
* Lunkenheimer Co.
* Reading Steel Casting Co. (Inc.)
* Vogt, Henry Machine Co.
Walworth Co.

Cocks, Blow-off
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
Walworth Co.
* Yarnall-Waring Co.

Cocks, Three-Way and Four-Way
* American Schaeffer & Budenberg Corp'n
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
Walworth Co.

Coils, Pipe
* Superheater Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.

Cold Storage Plants
* De La Vergne Machine Co.

Collars, Shafting
* Chain Belt Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
Wood's, T. B. Sons Co.

Coloring (Metal)
* American Metal Treatment Co.

Combustion (CO_2) Recorders
* Sarco Co. (Inc.)

Compressors, Air
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* Fairbanks, Morse & Co.
* General Electric Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Machinery Corp'n

Compressors, Air, Centrifugal
American Brown Boveri Elec. Corp'n
* De Laval Steam Turbine Co.
* General Electric Co.

Compressors, Air, Compound
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Compressors, Ammonia
* Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.
* Worthington Pump & Machinery Corp'n

Compressors, Gas
American Brown Boveri Elec. Corp'n
* De Laval Steam Turbine Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Machinery Corp'n

Condensers, Ammonia
* De La Vergne Machine Co.
* Frick Co. (Inc.)
* Ingersoll-Rand Co.
Struthers-Wells Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.

Condensers, Barometric
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
Elliott Co.
* Ingersoll-Rand Co.
Kellogg, M. W. Co.
Struthers-Wells Co.
* U. S. Cast Iron Pipe & Fdry. Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Condensers, Jet
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
Elliott Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Condensers, Surface
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
Elliott Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Condensation Return Systems
* Economy Pumping Machinery Co.

Conduits
Johns-Manville (Inc.)

Controllers, Automatic, for Temperature or for Pressure
(See Regulators)

Controllers, Condensate
* American Schaeffer & Budenberg Corp'n

Controllers, Damper
* American Schaeffer & Budenberg Corp'n

Controllers, Electric
Allen-Bradley Co.
American Brown Boveri Elec. Corp'n
Cutler-Hammer Mfg. Co.
* General Electric Co.

Controllers, Filter Rate
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Controllers, Liquid Level
* American Schaeffer & Budenberg Corp'n
* General Electric Co.
* Simplex Valve & Meter Co.

Controllers, Pressure
* American Schaeffer & Budenberg Corp'n

Controllers, Valve, Electrically Operated
Cutler-Hammer Mfg. Co.
* Liberty Electric Corp'n

Converters, Rotary
American Brown Boveri Elec. Corp'n

Converters, Synchronous
* Allis-Chalmers Mfg. Co.
* General Electric Co.
Ridgway Dynamo & Engine Co.

Conveying Machinery
* Chain Belt Co.
* Combustion Engineering Corp'n
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Murray, D. J. Mfg. Co.
* Palmer-Bee Co.

Conveying Systems, Pneumatic (Powdered Coal)
* Fuller-Lehigh Co.

Conveyor Systems, Pneumatic
* Allington & Curtis Mfg. Co.
* Sturtevant; B. F. Co.

Conveyors, Belt
* Chain Belt Co.
* Jeffrey Mfg. Co.

Conveyors, Bucket, Pan or Apron
* Chain Belt Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.

Conveyors, Chain
* Chain Belt Co.
* Jeffrey Mfg. Co.
* Murray, D. J. Mfg. Co.

Conveyors, Ice
* Chain Belt Co.
* Jeffrey Mfg. Co.
* Murray, D. J. Mfg. Co.

Conveyors, Portable
* Jeffrey Mfg. Co.

Conveyors, Screw
* Chain Belt Co.
* Jeffrey Mfg. Co.

Cooling Ponds, Spray
* Cooling Tower Co. (Inc.)
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Cooling Towers
* Burhorn, Edwin Co.
* Cooling Tower Co. (Inc.)
* Murray, D. J. Mfg. Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Copper, Drawn
* Roebling's, John A. Sons Co.

Copper Converting Machinery
* Allis-Chalmers Mfg. Co.

Counters, Revolution
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Bristol Co.
Veeder Mfg. Co.

Countershafts
* Builders Iron Foundry
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Murray, D. J. Mfg. Co.
Wood's, T. B. Sons Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers

CLASSIFIED LIST OF MECHANICAL EQUIPMENT

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Couplings, Pipe
Byers, A. M. Company
* Lunkenheimer Co.
Walworth Co.

Couplings, Shaft (Flexible)
* Allis-Chalmers Mfg. Co.
* Bartlett-Hayward Co.
Brown, A. & F. Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Nordberg Mfg. Co.
* Philadelphia Gear Works
* Smith & Serrell
* Terry Steam Turbine Co.

Couplings, Shaft (Rigid)
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
* Chain Belt Co.
Cumberland Steel Co.
* De Laval Steam Turbine Co.
* Falls Clutch & Machinery Co.
* Farrel Foundry & Machine Co.
* General Electric Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
* Smith & Serrell
Wood's, T. B. Sons Co.

Couplings, Universal
Cooper Flexible Transmission Co.
Wood's, T. B. Sons Co.

Coverings, Steam Pipe
Carey, Philip Co.
* Celite Products Co.
Johns-Manville (Inc.)
Walworth Co.

Cranes, Electric Traveling
* Palmer-Bee Co.
Shepard Electric Crane & Hoist Co.

Cranes, Hand Power
Clyde Iron Works Sales Co.
* Palmer-Bee Co.
Shepard Electric Crane & Hoist Co.

Cranes, Jib
* Palmer-Bee Co.
Shepard Electric Crane & Hoist Co.
* Yale & Towne Mfg. Co.

Cranes, Overhead
* Yale & Towne Mfg. Co.

Cranes, Portable
Clyde Iron Works Sales Co.

Cranes, Traveling
* Yale & Towne Mfg. Co.

Crucibles, Graphite
Dixon, Joseph Crucible Co.

Crushers, Clinker
* Farrel Foundry & Machine Co.
* Jeffrey Mfg. Co.

Crushers, Coal
* Allis-Chalmers Mfg. Co.
* Erie City Iron Works
* Fuller-Lehigh Co.
* Jeffrey Mfg. Co.
* Pennsylvania Crusher Co.
* Smidth, F. L. & Co.

Crushers, Hammer
* Jeffrey Mfg. Co.
* Pennsylvania Crusher Co.

Crushers, Jaw
* Farrel Foundry & Machine Co.

Crushers, Ore and Rock
* Farrel Foundry & Machine Co.
* Fuller-Lehigh Co.
* Nordberg Mfg. Co.
* Pennsylvania Crusher Co.

Crushers, Roll
* Fuller-Lehigh Co.
* Jeffrey Mfg. Co.
* Pennsylvania Crusher Co.

Crushing and Grinding Machinery
* Allis-Chalmers Mfg. Co.
* Farrel Foundry & Machine Co.
* Jeffrey Mfg. Co.
* Pennsylvania Crusher Co.
* Smidth, F. L. & Co.

Cupolas
* Bigelow Co.

Cups, Oil
* Gits Bros. Mfg. Co.
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)
Walworth Co.

Cutters, Milling
* Whitney Mfg. Co.

Cutters, Pipe
Walworth Co.

Cutting Machines, Paper, Cloth Leather, Rubber, etc.
Racine Tool & Machine Co.

Cutting-off Machines, Metal
Racine Tool & Machine Co.

Deaerators
* Cochrane Corp'n
Elliott Co.

Dehumidifying Apparatus
* Carrier Engineering Corp'n
* Sturtevant, B. F. Co.

Derricks and Derrick Fittings
Clyde Iron Works Sales Co.

Diaphragms, Rubber
* United States Rubber Co.

Die Heads, Thread Cutting (Self-opening)
* Jones & Lamson Machine Co.

Dies, Punching
Niagara Machine & Tool Works

Dies, Sheet Metal Working
Niagara Machine & Tool Works

Dies, Stamping
Niagara Machine & Tool Works

Dies, Thread Cutting
* Jones & Lamson Machine Co.
Walworth Co.

Digesters
* Bigelow Co.
* Erie City Iron Works

Digesters, Welded
* Erie City Iron Works
Kellogg, M. W. Co.

Distilling Apparatus
* Vogt, Henry Machine Co.

Drafting Room Furniture
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)

Drawing Instruments and Materials
Altenedер, Theo. & Sons
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)

Dredges, Hydraulic
American Brown Boveri Elec. Corp'n
* Morris Machine Works

Dredging Machinery
American Brown Boveri Elec. Corp'n
* Morris Machine Works

Dredging Sleeves
* United States Rubber Co.

Drills, Coal and Slate
* General Electric Co.
* Ingersoll-Rand Co.
* Jeffrey Mfg. Co.

Drills, Core
* Ingersoll-Rand Co.

Drills, Rock
* General Electric Co.
* Ingersoll-Rand Co.

Drinking Fountains, Sanitary
Johns-Manville (Inc.)

Dryers, Coal
* Fuller-Lehigh Co.
* Hardinge Co.

Dryers, Direct Heat
* Fuller-Lehigh Co.
* Hardinge Co.

Dryers, Indirect Heat
* Fuller-Lehigh Co.

Dryers, Rotary
* Bigelow Co.
* Erie City Iron Works
* Farrel Foundry & Machine Co.
* Fuller-Lehigh Co.
* Hardinge Co.
Kellogg, M. W. Co.
* Sturtevant, B. F. Co.

Dryers, Shell, Steam Jacketed
* Fuller-Lehigh Co.
* Hardinge Co.

Drying Apparatus
Buffalo Forge Co.
* Carrier Engineering Corp'n
* Sturtevant, B. F. Co.

Drying Machinery
* Hardinge Co.

Dust Collecting Systems
* Allington & Curtis Mfg. Co.
* Allis-Chalmers Mfg. Co.
* Erie City Iron Works
* Sturtevant, B. F. Co.

Dust Collectors
* Allington & Curtis Mfg. Co.
* Allis-Chalmers Mfg. Co.
* Erie City Iron Works
* Hardinge Co.
* Murray, D. J. Mfg. Co.
* Sturtevant, B. F. Co.

Dynamometers
* American Schaeffer & Budenberg Corp'n
* General Electric Co.
* Wheeler, C. H. Mfg. Co.

Economizers, Fuel
* Green Fuel Economizer Co.
* Power Specialty Co.
* Sturtevant, B. F. Co.

Ejectors
* Chicago Pump Co.
Elliott Co.
* Schutte & Koerting Co.

Electrical Machinery
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* General Electric Co.

Electrical Supplies
* General Electric Co.
Johns-Manville (Inc.)

Elevating and Conveying Machinery
* Chain Belt Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Murray, D. J. Mfg. Co.
* Palmer-Bee Co.

Elevators, Electric
* American Machine & Fdry Co.

Elevators, Inclined
* Jeffrey Mfg. Co.

Elevators, Portable
* Jeffrey Mfg. Co.

Elevators, Telescopic
* Jeffrey Mfg. Co.

Engine Repairs
* Franklin Machine Co.
* Murray, D. J. Mfg. Co.
* Nordberg Mfg. Co.

Engine Stops
* Schutte & Koerting Co.

Engines, Blowing
* Allis-Chalmers Mfg. Co.
* Nordberg Mfg. Co.

Engines, Gas
* Allis-Chalmers Mfg. Co.
* De La Vergne Machine Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Worthington Pump & Machinery Corp'n

Engines, Gasoline
* Fairbanks, Morse & Co.
* Sturtevant, B. F. Co.

Engines, Hoisting
* Allis-Chalmers Mfg. Co.
Clyde Iron Works Sales Co.
* Fairbanks, Morse & Co.
* Morris Machine Works
* Nordberg Mfg. Co.

Engines, Marine
American Brown Boveri Elec. Corp'n
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
Johnson, Carlyle Machine Co.
* Nordberg Mfg. Co.
* Sturtevant, B. F. Co.

Engines, Marine, Oil
American Brown Boveri Elec. Corp'n
* De La Vergne Machine Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Engines, Marine, Steam
* Nordberg Mfg. Co.

Engines, Oil
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* Bethlehem Steel Co.
* De La Vergne Machine Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Machinery Corp'n

Engines, Oil, Diesel
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* Bethlehem Steel Co.
* De La Vergne Machine Co.
* Nordberg Mfg. Co.

Engines, Pumping
* Allis-Chalmers Mfg. Co.
* De La Vergne Machine Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Morris Machine Works
* Nordberg Mfg. Co.

Engines, Steam
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
Clyde Iron Works Sales Co.
* Cole, R. D. Mfg. Co.
* Erie City Iron Works
Harrisburg Fdry. & Mach. Wks.
* Ingersoll-Rand Co.
* Leffel, James & Co.
* Morris Machine Works
* Nordberg Mfg. Co.
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.
* Sturtevant, B. F. Co.
* Troy Engine & Machine Co.
* Vilter Mfg. Co.
* Wheeler, C. H. Mfg. Co.

Engines, Steam Automatic
* Erie City Iron Works
Harrisburg Fdry. & Mach. Wks.
* Leffel, James & Co.
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.
* Sturtevant, B. F. Co.
* Troy Engine & Machine Co.

Engines, Steam, Corliss
* Allis-Chalmers Mfg. Co.
* Franklin Machine Co.
* Frick Co. (Inc.)
Harrisburg Fdry. & Mach. Wks.
* Nordberg Mfg. Co.
* Vilter Mfg. Co.

Engines, Steam, High Speed
* Erie City Iron Works
Harrisburg Fdry. & Mach. Wks.
* Nordberg Mfg. Co.
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.

Engines, Steam, Poppet Valve
* Erie City Iron Works
* Nordberg Mfg. Co.
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.
* Vilter Mfg. Co.

Engines, Steam, Throttling
* Erie City Iron Works
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.

Engines, Steam, Una-Flow
* Erie City Iron Works
* Frick Co. (Inc.)
Harrisburg Fdry. & Mach. Wks.
* Nordberg Mfg. Co.
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.

Engines, Steam, Variable Speed
* Erie City Iron Works
Harrisburg Fdry. & Mach. Wks.
* Nordberg Mfg. Co.
Ridgway Dynamo & Engine Co.
* Skinner Engine Co.

Engines, Steam, Vertical (Fully Enclosed, Self-Oiling)
* Troy Engine & Machine Co.

Engines, Steering
* Bethlehem Steel Co.

Evaporators
* Bartlett-Hayward Co.
* Bethlehem Steel Co.
* Croll-Reynolds Engrg. Co.
* Farrel Foundry & Machine Co.
* Murray, D. J. Mfg. Co.
* Schutte & Koerting Co.
* Vogt, Henry Machine Co.
* Wheeler Condenser & Engrg. Co.

Excavating Machinery
Clyde Iron Works Sales Co.

Exhaust Heads
Hoppes Mfg. Co.
* Kieley & Mueller (Inc.)
Ruggles-Klingemann Mfg. Co.
* Sturtevant, B. F. Co.
Walworth Co.

Exhaust Systems
* Allington & Curtis Mfg. Co.
* Sturtevant, B. F. Co.

Exhausters, Gas
American Brown Boveri Elec. Corp'n
Buffalo Forge Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Ingersoll-Rand Co.
* Schutte & Koerting Co.
* Sturtevant, B. F. Co.
* Wing, L. J. Mfg. Co.

Experimental Work
International Pattern Corp'n

Extractors, Centrifugal
Tolhurst Machine Works

Extractors, Oil and Grease
* American Schaeffer & Budenberg Corp'n
Elliott Co.
* Kieley & Mueller (Inc.)

Fans, Exhaust
Buffalo Forge Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Jeffrey Mfg. Co.
* Murray, D. J. Mfg. Co.
* Sturtevant, B. F. Co.
* Wing, L. J. Mfg. Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 120

Fans, Exhaust, Mine
Buffalo Forge Co.
* Jeffrey Mfg. Co.
* Sturtevant, B. F. Co.

Feeders, Pulverized Fuel
* Combustion Engineering Corp'n
* Fuller-Lehigh Co.
* Hardinge Co
* Smidth, F. L. & Co.

Filing Machines
Racine Tool & Machine Co.

Filters, Air
* Cooling Tower Co. (Inc.)
Staynew Filter Corp'n

Filters, Bone Black
* Murray, D. J. Mfg. Co.

Filters, Feed Water, Boiler
* Cochrane Corp'n
Elliott Co.
* Graver Corp'n
* International Filter Co.
* Paige & Jones Chemical Co.(Inc.)
* Permutit Co.
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.

Filters, Feed Water, Demulsifying
* Permutit Co.
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.

Filters, Gravity
* Graver Corp'n
* International Filter Co.
* Permutit Co.
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.

Filters, Mechanical
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B. & Sons Co.

Filters, Oil
Elliott Co.
* General Electric Co.
* Nugent, Wm. W. & Co. (Inc.)
* Permutit Co.

Filters, Pressure
* Cochrane Corp'n
* Graver Corp'n
* International Filter Co.
* Paige & Jones Chemical Co. (Inc.)
* Permutit Co.
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.

Filtration Plants, Industrial
* Cochrane Corp'n
* Graver Corp'n
* International Filter Co.
* Permutit Co.
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.

Fire Door Protectors, Water Cooled
Lamprey Co.

Fittings, Ammonia
* De La Vergne Machine Co.
* Frick Co. (Inc.)
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.
Walworth Co.

Fittings, Compression
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)

Fittings, Flanged
* Builders Iron Foundry
* Edward Valve & Mfg. Co.
* Kennedy Valve Mfg. Co.
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
* U. S. Cast Iron Pipe & Fdry. Co.
* Vogt, Henry Machine Co.
Walworth Co.

Fittings, Hydraulic
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
* Vogt, Henry Machine Co.
Walworth Co.

Fittings, Pipe
* Barco Mfg. Co.
* Kennedy Valve Mfg. Co.
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
* Vogt, Henry Machine Co.
Walworth Co.

Fittings, Steel
* Edward Valve & Mfg. Co.
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
* Vogt, Henry Machine Co.
Walworth Co.

Flanges
* American Spiral Pipe Works
* Edward Valve & Mfg. Co.
* Kennedy Valve Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co
* Reading Steel Casting Co. (Inc.)
* Vogt, Henry Machine Co.
Walworth Co.

Flanges, Forged Steel
* American Spiral Pipe Works
Cann & Saul Steel Co.
Walworth Co.

Floor Stands
* Chapman Valve Mfg. Co.
Hill Clutch Mach. & Fdry. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Kennedy Valve Mfg. Co.
* Lunkenheimer Co.
* Murray, D. J. Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Wood's, T. B. Sons Co.

Flooring, Grating
* Hendrick Mfg. Co.
* Irving Iron Works Co.

Flooring, Metallic
* Hendrick Mfg. Co.
* Irving Iron Works Co.

Flooring, Rubber
* United States Rubber Co.

Flour Milling Machinery
* Allis-Chalmers Mfg. Co.

Fly Wheels
Hill Clutch Mach. & Fdry. Co.
* Medart Co.
* Norberg Mfg. Co.
Wood's, T. B. Sons Co.

Forges
Buffalo Forge Co.

Forgings, Chrome Steel
Skodaworks (Arthur J. Herschmann)

Forgings, Drop
* Bethlehem Steel Co.
Skodaworks (Arthur J. Herschmann)
* Vogt, Henry Machine Co.

Forgings, Hammered
* Bethlehem Steel Co.
Skodaworks (Arthur J. Herschmann)
Cann & Saul Steel Co.

Forgings, Heavy
Skodaworks (Arthur J. Herschmann)

Forgings, Iron and Steel
* Bethlehem Steel Co.
Cann & Saul Steel Co.

Forgings, Monel Metal
* International Nickel Co.

Forgings, Nickel
* International Nickel Co.

Forgings, Steel
Skodaworks (Arthur J. Herschmann)

Furnaces, Annealing and Tempering
* Combustion Engineering Corp'n
* Erie City Iron Works
* General Electric Co.

Furnaces, Boiler
* American Engineering Co.
* American Spiral Pipe Works
* Babcock & Wilcox Co.
* Bernitz Furnace Appliance Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Riley Stoker Corp'n

Furnaces, Boiler (Water Cooled)
* Combustion Engineering Corp'n
* Erie City Iron Works

Furnaces, Electric
American Brown Boveri Elec. Corp'n
Detroit Electric Furnace Co.
* General Electric Co.

Furnaces, Heat Treating
* Combustion Engineering Corp'n
* Erie City Iron Works
* General Electric Co.

Furnaces, Melting
* Combustion Engineering Corp'n
Detroit Electric Furnace Co.
* Erie City Iron Works
* Fuller-Lehigh Co.
* General Electric Co.

Furnaces, Non-Ferrous
* Combustion Engineering Corp'n
Detroit Electric Furnace Co.
* Erie City Iron Works

Furnaces, Powdered Coal
* Combustion Engineering Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Furnace Engineering Co.

Furnaces, Smokeless
* American Engineering Co.
* Babcock & Wilcox Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Riley Stoker Corp'n

Fuses
* General Electric Co.
Johns-Manville (Inc.)

Gage Boards
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Brown Instrument Co.

Gage Glasses
* American Schaeffer & Budenberg Corp'n
* Jenkins Bros.
Walworth Co.

Gage Testers
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.

Gages, Altitude
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.

Gages, Ammonia
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Bristol Co.
* Vogt, Henry Machine Co.

Gages, Differential Pressure
* American Schaeffer & Budenberg Corp'n
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Brown Instrument Co.

Gages, Draft
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Taylor Instrument Cos.

Gages, Hydraulic
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.

Gages, Liquid Depth
* Brown Instrument Co.

Gages, Liquid Level
* Bristol Co.
* Lunkenheimer Co.
* Simplex Valve & Meter Co.

Gages, Loss of Head
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Gages, Measuring (Surface, Depth, Dial, etc.)
* Norma-Hoffmann Bearings Corp'n

Gages, Pressure
* American Schaeffer & Budenberg Corp'n.
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.

Gages, Rate of Flow
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Gages, Vacuum
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bristol Co.
* Brown Instrument Co.
* Taylor Instrument Cos.

Gages, Water
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Bristol Co.
* Jenkins Bros.
* Lunkenheimer Co.
* Reading Steel Casting Co. (Inc.)
* Simplex Valve & Meter Co.

Gages, Water Inclined
Sesure Water Gauge Co.

Gages, Water Level
* American Schaeffer & Budenberg Corp'n
* Bristol Co.
* Brown Instrument Co.
* Lunkenheimer Co.
* Simplex Valve & Meter Co.

Gages, Water Level, Boiler
* Brown Instrument Co.

Gas Holders
* Bartlett-Hayward Co.
* Graver Corp'n

Gas Plant Machinery
* Bartlett-Hayward Co.
* Cole, R. D. Mfg. Co.

Gas Plants
* Bartlett-Hayward Co.

Gaskets
* Garlock Packing Co.
* Jenkins Bros.
Johns-Manville (Inc.)
* Sarco Co. (Inc.)
Walworth Co.

Gaskets, Iron, Corrugated
Smooth-On Mfg. Co.

Gaskets, Rubber
* Garlock Packing Co.
* United States Rubber Co.

Gasoline
Tide Water Oil Sales Corp'n

Gates, Cut-off
* Jeffrey Mfg. Co.

Gates, Sluice
* Chapman Valve Mfg. Co.
Ludlow Valve Mfg. Co.
* Murray, D. J. Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co.

Gear Blanks
Cann & Saul Steel Co.
* Murray, D. J. Mfg. Co.

Gear Cutting Machines
* Jones, W. A. Fdry. & Mach. Co.

Gear Hobbing Machines
* Jones, W. A. Fdry. & Mach. Co.

Gears, Bronze
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Murray, D. J. Mfg. Co.
* Philadelphia Gear Works

Gears, Cut
Brown, A. & F. Co.
* Chain Belt Co.
* De Laval Steam Turbine Co.
* Farrel Foundry & Machine Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
Hill Clutch Mach. & Fdry. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Jeffrey Mfg. Co.
Johnson, Carlyle Machine Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Philadelphia Gear Works

Gears, Fibre
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* General Electric Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Philadelphia Gear Works

Gears, Helical
* De Laval Steam Turbine Co.
Elliott Co.
* Farrel Foundry & Machine Co.
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Philadelphia Gear Works
* Terry Steam Turbine Co.

Gears, Herringbone
Elliott Co.
* Falk Corporation
* Farrel Foundry & Machine Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Philadelphia Gear Works
* Terry Steam Turbine Co.

Gears, Machine Molded
Brown, A. & F. Co.
* Farrel Foundry & Machine Co.
* Jones, W. A. Fdry. & Mach. Co.
* Murray, D. J. Mfg. Co.

Gears, Phenalic Composition
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Philadelphia Gear Works

Gears, Ratchet
* Philadelphia Gear Works

Gears, Rawhide
* Farrel Foundry & Machine Co.
* Foote Bros. Gear & Machine Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 120

* Ganschow, Wm. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Philadelphia Gear Works

Gears, Speed Reduction
* American Fluid Motors Co.
* Chain Belt Co.
* De Laval Steam Turbine Co.
Elliott Co.
* Falk Corporation
* Farrel Foundry & Machine Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* General Electric Co.
Hill Clutch Mach. & Fdry. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Moore Steam Turbine Corp'n
* Palmer-Bee Co.
* Philadelphia Gear Works
Shepard Electric Crane & Hoist Co.
* Sturtevant, B. F. Co.
* Terry Steam Turbine Co.

Gears, Spur
* Horsburgh & Scott Co.
* Philadelphia Gear Works

Gears, Steel
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
Hill Clutch Mach. & Fdry. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Philadelphia Gear Works

Gears, Worm
* Chain Belt Co.
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Murray, D. J. Mfg. Co.
* Philadelphia Gear Works

Generating Sets
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
Ridgway Dynamo & Engine Co.
* Sturtevant, B. F. Co.
* Terry Steam Turbine Co.

Generator Cooling Systems
Carrier Air Conditioning Co.
* Schutte & Koerting Co.

Generators, Electric
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Nordberg Mfg. Co.
Ridgway Dynamo & Engine Co.
* Terry Steam Turbine Co.

Governors, Air, Compressor
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
Walworth Co.

Governors, Engine, Oil
* Nordberg Mfg. Co.

Governors, Engine, Steam
Cory, Chas. & Son (Inc.)
* Nordberg Mfg. Co.
Walworth Co.

Governors, Oil Burner
* Mason Regulator Co.

Governors, Oil Operation
* Kieley & Mueller (Inc.)

Governors, Pump
* Edward Valve & Mfg. Co.
* d'Este, Julian Co.
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
Squires, C. E. Co.
Walworth Co.

Governors, Steam Turbine
Cory, Chas. & Son (Inc.)

Granulators
* Smidth, F. L. & Co.

Graphite, Flake (Lubricating)
Dixon, Joseph Crucible Co.

Grate Bars
* Casey-Hedges Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Murray, D. J. Mfg. Co.
* Vogt, Henry Machine Co.

Grate Bars (for Overfeed and Underfeed Stokers)
* Erie City Iron Works
* Furnace Engineering Co.

Grates, Dumping
* Combustion Engineering Corp'n
* Erie City Iron Works
* Vogt, Henry Machine Co.

Grates, Shaking
* Casey-Hedges Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Springfield Boiler Co.
* Vogt, Henry Machine Co.

Grating, Sidewalk
* Hendrick Mfg. Co.
* Irving Iron Works Co.

Grease Cups
Walworth Co.

Greases
Dixon, Joseph Crucible Co.
Tide Water Oil Sales Corp'n
Vacuum Oil Co.

Grinding Machinery
Brown, A. & F. Co.
* Smidth, F. L. & Co.

Grinding Machines
* American Machine & Fdry. Co.

Grinding Machines, Floor
* Builders Iron Foundry

Grinding Machines, Pneumatic, Portable
* Ingersoll-Rand Co.
* Warner & Swasey Co.

Gun Metal Finish
* American Metal Treatment Co.

Hammers, Drop
* Franklin Machine Co.

Hammers, Pneumatic
* Ingersoll-Rand Co.

Handles, Machine, Steel
Rockwood Sprinkler Co.

Hangers, Shaft
Brown, A. & F. Co.
* Chain Belt Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
Wood's, T. B. Sons Co.

Hangers, Shaft (Ball Bearing)
* Hyatt Roller Bearing Co.

Hangers, Shaft (Roller Bearing)
* Hyatt Roller Bearing Co.
* Jones, W. A. Fdry. & Mach. Co.

Hard Rubber Products
* United States Rubber Co.

Hardening
* American Metal Treatment Co.

Headers, Welded
Kellogg, M. W. Co.
Walworth Co.

Heat Exchangers
* Croll-Reynolds Engineering Co.
* Schutte & Koerting Co.
Struthers-Wells Co.

Heat Treating
* American Metal Treatment Co.

Heaters, Feed Water (Cosed)
* Bethlehem Steel Co.
* Cochrane Corp'n
* Croll-Reynolds Engineering Co.
Elliott Co.
* Erie City Iron Works
* Schutte & Koerting Co.
* Walsh & Weidner Boiler Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Cond. & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Heaters, Oil
* Power Specialty Co.
* Schutte & Koerting Co.

Heaters and Purifiers, Feed Water, Metering
* Cochrane Corp'n

Heaters and Purifiers, Feed Water (Open)
* Cochrane Corp'n
Elliott Co.
* Erie City Iron Works
* Graver Corp'n
Hoppes Mfg. Co.
* Springfield Boiler Co.
* Wickes Boiler Co.
* Worthington Pump & Machinery Corp'n

Heating Devices, Electric
Cutler-Hammer Mfg. Co.
* General Electric Co.

Heating Specialties
* Fulton Co.
* Kieley & Mueller (Inc.)

Heating Systems, Hot Blast, Direct Fired
Buffalo Forge Co.

Heating and Ventilating Apparatus
Buffalo Forge Co.
* Sturtevant, B. F. Co.

Hoisting and Conveying Machinery
* Chain Belt Co.
Clyde Iron Works Sales Co.
* Jeffrey Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
Shepard Electric Crane & Hoist Co.

Hoists, Air
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Palmer-Bee Co.

Hoists, Belt
Clyde Iron Works Sales Co.

Hoists, Chain
* Palmer-Bee Co.
* Yale & Towne Mfg. Co.

Hoists, Electric
* Allis-Chalmers Mfg. Co.
* American Engineering Co.
Clyde Iron Works Sales Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Nordberg Mfg. Co.
Shepard Electric Crane & Hoist Co.
* Yale & Towne Mfg. Co.

Hoists, Gate
* Murray, D. J. Mfg. Co.

Hoists, Hand
* Yale & Towne Mfg. Co.

Hoists, Head Gate
* Smith, S. Morgan Co.

Hoists, Mine
* Nordberg Mfg. Co.

Hoists, Skip
* Jeffrey Mfg. Co.
* Palmer-Bee Co.

Hoppers, Coal and Ash
* Breese Bros. Co.
* Jeffrey Mfg. Co.

Hose, Acid
* United States Rubber Co.

Hose, Air
* United States Rubber Co.

Hose, Fire
* United States Rubber Co.

Hose, Gas
* Ingersoll-Rand Co.
* United States Rubber Co.

Hose, Gasoline
* United States Rubber Co.

Hose, Metal, Flexible
Cory, Chas. & Son (Inc.)
Johns-Manville (Inc.)

Hose, Oil
* United States Rubber Co.

Hose, Rubber
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* United States Rubber Co.

Hose, Steam
* Ingersoll-Rand Co.
* United States Rubber Co.

Hose, Suction
* Fairbanks, Morse & Co.
* United States Rubber Co.

Humidifiers
Carrier Air Conditioning Co.
* Carrier Engineering Corp'n
* Sturtevant, B. F. Co.

Humidity Control
* Carrier Engineering Corp'n
* Sturtevant, B. F. Co.

Hydrants, Fire
* Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
* Reading Steel Casting Co. (Inc.)

Hydraulic Machinery
* Allis-Chalmers Mfg. Co.
* Ingersoll-Rand Co.

Hydraulic Press Control Systems (Oil Pressure)
* American Fluid Motors Co.

Hydrokineters
* Schutte & Koerting Co.

Hydrometers
* Taylor Instrument Cos.

Hygrometers
* American Schaeffer & Budenberg Corp'n
Bristol Co.
* Brown Instrument Co.
* Taylor Instrument Cos.
Weber, F. Co. (Inc.)

Ice Handling Machinery
* Jeffrey Mfg. Co.
* Palmer-Bee Co.

Ice Making Machinery
* De La Vergne Machine Co.
* Frick Co. (Inc.)
* Ingersoll-Rand Co.
Johns-Manville (Inc.)
* Nordberg Mfg. Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.

Idlers, Belt
Hill Clutch Mach. & Fdry. Co.
* Murray, D. J. Mfg. Co.
* Smidth, F. L. & Co.

Indicator Posts
* Kennedy Valve Mfg. Co.
* Reading Steel Casting Co. (Inc.)
Walworth Co.

Indicators, CO
* Brown Instrument Co.

Indicators, CO_2
Bacharach Industrial Instrument Co.
* Brown Instrument Co.

Indicators, Draft
* Brown Instrument Co.

Indicators, Engine
* American Schaeffer & Budenberg Corp'n
Bacharach Industrial Instrument Co.

Indicators, Liquid Level
* Brown Instrument Co.
Cutler-Hammer Mfg. Co.

Indicators, SO_2
* Brown Instrument Co.

Indicators, Speed
* American Schaeffer & Budenberg Corp'n
* Bristol Co.
* Brown Instrument Co.
Cory, Chas. & Son (Inc.)
Veeder Mfg. Co.

Indicators, Valve Opening Position
Cutler-Hammer Mfg. Co.

Indicators, Water Line
* American Schaeffer & Budenberg Corp'n

Injectors
* Schutte & Koerting Co.

Injectors, Air
* Croll-Reynolds Engineering Co.

Instruments, Electrical Measuring
* Bristol Co.
* Brown Instrument Co.
* General Electric Co.
* Taylor Instrument Cos.

Instruments, Recording
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Builders Iron Foundry
* General Electric Co.
* Taylor Instrument Cos.
* Yarnall-Waring Co.

Instruments, Scientific
* American Schaeffer & Budenberg Corp'n
* Brown Instrument Co.
* Taylor Instrument Cos.
Weber, F. Co. (Inc.)

Instruments, Surveying
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)

Insulating Materials (Electrical)
* General Electric Co.
Johns-Manville (Inc.)

Insulating Materials (Heat and Cold)
Carey, Philip Co.
* Celite Products Co.
Johns-Manville (Inc.)
* King Refractories Co. (Inc.)
* Quigley Furnace Specialties Co.

nsulation, Boiler
Carey, Philip Co.
* Celite Products Co.

Insulation, Heat
Carey, Philip Co.
* Celite Products Co.

Joints, Expansion
* Barco Mfg. Co.
Carey, Philip Co.
* Croll-Reynolds Engineering Co.
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* United States Rubber Co.
Walworth Co.
* Wheeler, C. H. Mfg. Co.

Joints, Flanged Pipe
* Barco Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co.
Walworth Co.

Joints, Flexible
* Barco Mfg. Co.

Joints, Swing and Swivel
* Barco Mfg. Co.
* Lunkenheimer Co.
Walworth Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment 1926-27 Volume*

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 120

Joints, Universal
Cooper Flexible Transmission Co.

Kerosene
Tide Water Oil Sales Corp'n
Kettles, Copper
* Breese Bros. Co.
Kettles, Steam Jacketed
* Cole, R. D. Mfg. Co.
* Nordberg Mfg. Co.
Keys, Machine
* Smith & Serrell
* Whitney Mfg. Co.
Keyseating Machines
* Whitney Mfg. Co.
Kilns, Dry (Brick, Lumber, Stone etc.)
* Sturtevant, B. F. Co.

Lamps, Incandescent
* General Electric Co.
Johns-Manville (Inc.)
Land-Clearing Machinery
Clyde Iron Works Sales Co.
Lathes, Automatic
* Jones & Lamson Machine Co.
Lathes, Brass
Warner & Swasey Co.
Lathes, Chucking
* Jones & Lamson Machine Co.
Lathes, Engine
* Builders' Iron Foundry
Lathes, Turret
* Jones & Lamson Machine Co.
Warner & Swasey Co.
Levers, Flexible (Wire)
* Gwilliam Co.
Lightning Arresters
American Brown Boveri Elec. Corp'n.
* General Electric Co.
Linings, Brake
Johns-Manville (Inc.)
Linings, Furnace
* Celite Products Co.
Johns-Manville (Inc.)
* King Refractories Co. (Inc.)
* McLeod & Henry Co.
* Quigley Furnace Specialties Co.
Linings, Stack
Johns-Manville (Inc.)
Loaders, Portable
* Jeffrey Mfg. Co.
Locomotives, Diesel-Electric
American Brown Boveri Elec. Corp'n
Locomotives, Electric
American Brown Boveri Elec. Corp'n
* General Electric Co.
* Jeffrey Mfg. Co.
Locomotives, Storage Battery
* General Electric Co.
* Jeffrey Mfg. Co.
Logging Machinery
Clyde Iron Works Sales Co.
Lubricants
Dixon, Joseph Crucible Co.
Tide Water Oil Sales Corp'n
Vacuum Oil Co.
Lubricating Systems
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)
Lubricators
* Gits Bros. Mfg. Co.
* Lunkenheimer Co.
Lubricators, Cylinder
* Lunkenheimer Co.
Lubricators, Force-Feed
* Lunkenheimer Co.
Lubricators, Hydrostatic
* Lunkenheimer Co.
Lubricators (Sight Feed)
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)

Machine Tool Feed Control Systems (Oil Pressure)
* American Fluid Motors Co.
Machine Work
Brown, A. & F. Co.
* Builders Iron Foundry
* Farrel Foundry & Machine Co.
* Franklin Machine Co.
Hill Clutch Machine & Fdry. Co.
International Pattern Corp'n
Johnson, Carlyle Machine Co.
* Jones, W. A. Fdry. & Mach. Co.
Lammert & Mann Co.
* Murray, D. J. Mfg. Co.
* Nordberg Mfg. Co.
Machine Work, Contract
* American Machine & Fdry. Co.
Machinery
(Is classified under the headings descriptive of character thereof)
Machinery Guards, Perforated Metal
* Breese Bros. Co.
Magnets, Lifting
Cutler-Hammer Mfg. Co.
Manometers
Bacharach Industrial Instrument Co.
* Simplex Valve & Meter Co.
Mechanical Draft Apparatus
* Air Preheater Corp'n
Buffalo Forge Co.
* Green Fuel Economizer Co.
* Jeffrey Mfg. Co.
* Sturtevant, B. F. Co.
Metal Treating
* American Metal Treatment Co.
Metals, Anti-Friction
* Magnolia Metal Co.
Metals, Bearing
* General Electric Co.
* Magnolia Metal Co.
Metals, Perforated
* Hendrick Mfg. Co.
Meters, Air and Gas
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
Cutler-Hammer Mfg. Co.
* General Electric Co.
Meters, Boiler Performance
* Bailey Meter Co.
* Worthington Pump & Machinery Corp'n
* Yarnall-Waring Co.
Meters, Condensation
* Simplex Valve & Meter Co.
Meters, Electric
* General Electric Co.
Meters, Feed Water
* Bailey Meter Co.
* Builders Iron Foundry
* Cochrane Corp'n
* General Electric Co.
Hoppes Mfg. Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Machinery Corp'n
* Yarnall-Waring Co.
Meters, Flow
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Brown Instrument Co.
* Cochrane Corp'n
Cory, Chas. & Son (Inc.)
* General Electric Co.
* Simplex Valve & Meter Co.
* Yarnall-Waring Co.
Meters, Oil
* Cochrane Corp'n
* General Electric Co.
* National Meter Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Machinery Corp'n
* Yarnall-Waring Co.
Meters, Pitot Tube
Cory, Chas. & Son (Inc.)
* Simplex Valve & Meter Co.
Meters, Steam
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Cochrane Corp'n
* General Electric Co.
Meters, V-Notch
* Bailey Meter Co.
* Cochrane Corp'n
* General Electric Co.
* Yarnall-Waring Co.
Meters, Venturi
* Builders Iron Foundry
* National Meter Co.
* Simplex Valve & Meter Co.
Meters, Water
* Cochrane Corp'n
* General Electric Co.
Hoppes Mfg. Co.
* National Meter Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Machinery Corp'n
* Yarnall-Waring Co.
Milling Machines, Hand
* Whitney Mfg. Co.
Milling Machines, Keyseat
* Whitney Mfg. Co.
Milling Machines, Plain
Warner & Swasey Co.
Mills, Ball
* Allis-Chalmers Mfg. Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Smidth, F. L. & Co.
Struthers-Wells Co.
Mills, Grinding
* Farrel Foundry & Machine Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Smidth, F. L. & Co.
Mills, Roller
* Fuller-Lehigh Co.
Mills, Tube
* Allis-Chalmers Mfg. Co.
* Smidth, F. L. & Co.
Mining Machinery
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Jeffrey Mfg. Co.
Models
International Pattern Corp'n
Monel Metal
* International Nickel Co.
Monorail Systems
(See Tramrail Systems, Overhead)
Motor-Generators
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* General Electric Co.
Ridgway Dynamo & Engine Co.
* Sturtevant, B. F. Co.
Motors, Electric
* Fairbanks, Morse & Co.
* General Electric Co.
Lincoln Elec. Co.
Ridgway Dynamo & Engine Co.
Shepard Electric Crane & Hoist Co.
* Sturtevant, B. F. Co.
Motors, Synchronous
Ridgway Dynamo & Engine Co

Nickel
* International Nickel Co.
Nitrogen Gas
* Linde Air Products Co.
Nozzles, Blast
* Schutte & Koerting Co.
Nozzles, Sand and Air
* Lunkenheimer Co.
Nozzles, Spray
Buffalo Forge Co.
* Cooling Tower Co. (Inc.)
* Murray, D. J. Mfg. Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.
Nuts, Lock
Palnut Co.

Odometers
Veeder Mfg. Co.
Ohmeters
Cory, Chas. & Son (Inc.)
* General Electric Co.
Oil and Grease Cups
* Lunkenheimer Co.
Walworth Co.
Oil Burning Equipment
* Bethlehem Steel Co.
* Combustion Engineering Corp'n
Lammert & Mann Co.
* Schutte & Koerting Co.
Oil Distributing Systems
* Nugent, Wm. W. & Co. (Inc.)
Oil Filtering and Circulating Systems
* Nugent, Wm. W. & Co. (Inc.)
Oil Refinery Equipment
* Bethlehem Steel Co.
* Graver Corp'n
Kellogg, M. W. Co.
Struthers-Wells Co.
* Vogt, Henry Machine Co.
Oil Storage Systems
* Nugent, Wm. W. & Co. (Inc.)
Oil Well Machinery
* Ingersoll-Rand Co.
Oiling Devices
* Gits Bros. Mfg. Co.
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)
Oiling Systems
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)
Oils, Fuel
Tide Water Oil Sales Corp'n
Oils, Lubricating
Tide Water Oil Sales Corp'n
Vacuum Oil Co.
Ore Concentration Machines
* Hardinge Co.
Ore Handling Machinery
* Chain Belt Co.
* Jeffrey Mfg. Co.
Ovens, Japanning
* Breese Bros. Co.
Oxy-Acetylene Supplies
* Linde Air Products Co.
Oxygen Gas
* Linde Air Products Co.

Packing, Acid Resisting
Crane Packing Co.
* Garlock Packing Co.
Packing, Ammonia
Crane Packing Co.
France Packing Co.
* Garlock Packing Co.
* United States Rubber Co.
Packing, Asbestos
* Garlock Packing Co.
Johns-Manville (Inc.)
Walworth Co.
Packing, Centrifugal Pump
Crane Packing Co.
* Garlock Packing Co.
Packing, Hydraulic
Crane Packing Co.
France Packing Co.
* Garlock Packing Co.
Johns-Manville (Inc.)
Walworth Co.
Packing, Metallic
Crane Packing Co.
France Packing Co.
* Garlock Packing Co.
Johns-Manville (Inc.)
Walworth Co.
Packing, Metallic Condenser
Crane Packing Co.
Packing, Rod (Piston and Valve)
Crane Packing Co.
France Packing Co.
* Garlock Packing Co.
* Jenkins Bros.
Johns-Manville (Inc.)
* United States Rubber Co.
Packing, Rubber
* Garlock Packing Co.
* Jenkins Bros.
Johns-Manville (Inc.)
* United States Rubber Co.
Walworth Co.
Packing, Sheet
* Garlock Packing Co.
* Jenkins Bros.
Johns-Manville (Inc.)
* United States Rubber Co.
Walworth Co.
Paint, Metal
Dixon, Joseph Crucible Co.
* General Electric Co.
Johns-Manville (Inc.)
Paints, Concrete (For Industrial Purposes)
Smooth-On Mfg. Co.
Pans, Copper
* Breese Bros. Co.
Paper, Drawing
Alteneder, Theo. & Sons
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)
Paper, Sensitized
Alteneder, Theo. & Sons
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)
Paper, Tracing
* Pease, C. F. Co.
Special Paper Mfg. Co.
Paper Mill Machinery
* Farrel Foundry & Machine Co.
* Murray, D. J. Mfg. Co.
Paraffine Wax Plant Equipment
* Bethlehem Steel Co.
* Graver Corp'n
Kellogg, M. W. Co.
* Vogt, Henry Machine Co.
Pasteurizers
* Vilter Mfg. Co.
Pattern Work
* American Machine & Fdry. Co.
International Pattern Corp'n
Pawls
* Philadelphia Gear Works
Pencils, Drawing
Alteneder, Theo. & Sons
American Lead Pencil Co.
Dietzgen, Eugene Co.
Dixon, Joseph Crucible Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)
Penstocks
* Graver Corp'n
Kellogg, M. W. Co.
* Smith, S. Morgan Co.
Struthers-Wells Co
Petroleum Products
Tide Water Oil Sales Corp'n
Pile Drivers
Clyde Iron Works Sales Co.
Pinions, Rolling Mill
* Foote Bros. Gear & Machine Co.
Pinions, Steel
* Foote Bros. Gear & Machine Co.
* General Electric Co.
Pipe, Brass and Copper
Walworth Co.
* Wheeler Condenser & Engrg. Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers **CLASSIFIED LIST OF MECHANICAL EQUIPMENT** Alphabetical List on page 120

Pipe, Cast Iron
* Builders Iron Foundry
* U. S. Cast Iron Pipe & Fdry. Co.
Walworth Co.

Pipe, Forge Welded
* American Spiral Pipe Works

Pipe, Riveted
* American Spiral Pipe Works
* Springfield Boiler Co.
Struthers-Wells Co.
* Walsh & Weidner Boiler Co.

Pipe, Spiral, Riveted
* American Spiral Pipe Works

Pipe, Steel
* Graver Corp'n
Struthers-Wells Co.

Pipe, Welded
* American Spiral Pipe Works
* Pittsburgh Valve, Fdry. & Const. Co.
Struthers-Wells Co.
Walworth Co.

Pipe, Wrought Iron
Byers, A. M. Company
Walworth Co.

Piping Ammonia
* Frick Co. (Inc.)

Piping, Power
Kellogg, M. W. Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Vogt, Henry Machine Co.
Walworth Co.

Planimeters
Alteneder, Theo. & Sons
* American Schaeffer & Budenberg Corp'n
* Bristol Co.
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)

Plugs, Fusible
Walworth Co.

Polishing Machines
* Builders Iron Foundry

Powdered Fuel Equipment (for Boiler and Metallurgical Furnaces)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Furnace Engineering Co.
* Hardinge Co.
* Quigley Furnace Specialties Co.
* Smidth, F. L. & Co.

Power Transmission Machinery
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
* Chain Belt Co.
* Diamond Chain & Mfg. Co.
* Falls Clutch & Machinery Co.
* Farrel Foundry & Machine Co.
* Foote Bros. Gear & Machine Co.
* Franklin Machine Co.
* General Electric Co.
Hill Clutch Mach. & Fdry. Co.
* Hyatt Roller Bearing Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Morse Chain Co.
* Murray, D. J. Mfg. Co.
* Palmer-Bee Co.
* Smidth, F. L. & Co.
* Smith, S. Morgan Co.
Wood's, T. B. Sons Co.

Preheaters, Air
* Air Preheater Corp'n
Buffalo Forge Co.
* Combustion Engineering Corp'n

Presses, Baling
* Franklin Machine Co.

Presses, Draw
Niagara Machine & Tool Works

Presses, Extruding
* Farrel Foundry & Machine Co.

Presses, Foot
Niagara Machine & Tool Works

Presses, Forming
* Farrel Foundry & Machine Co.
Niagara Machine & Tool Works

Presses, Hydraulic
* Falls Clutch & Machinery Co.
* Farrel Foundry & Machine Co.

Presses, Power
Niagara Machine & Tool Works

Presses, Punching and Trimming
Niagara Machine & Tool Works

Presses, Sheet Metal Working
Niagara Machine & Tool Works

Presses, Toggle
* Bethlehem Steel Co.
Niagara Machine & Tool Works

Presses, Wax
* Vogt, Henry Machine Co.

Producers, Gas
* Bartlett-Hayward Co.
* De La Vergne Machine Co.

Propellers
* Morris Machine Works

Pulleys, Friction Clutch
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
Johnson, Carlyle Mach. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
* Wood's, T. B. Sons Co.

Pulleys, Iron
Brown, A. & F. Co.
* Chain Belt Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
Wood's T. B. Son's Co.

Pulleys, Steel
* Medart Co.

Pulleys, Wood
* Medart Co.

Pulverized Fuel Unit Systems
* Aero Pulverizer Co.
* Bethlehem Steel Co.
* Furnace Engineering Co.
* Riley Stoker Corp'n

Pulverizers
* Bethlehem Steel Co.
Brown, A. & F. Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Hardinge Co.
* Jeffrey Mfg. Co.
* Smidth, F. L. & Co.

Pulverizers, Cement Material
* Bethlehem Steel Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Pennsylvania Crusher Co.

Pulverizers, Coal
* Aero Pulverizer Co.
* Bethlehem Steel Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Furnace Engineering Co.
* Hardinge Co.
* Jeffrey Mfg. Co.
* Pennsylvania Crusher Co.

Pulverizers, Limestone
* Bethlehem Steel Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Jeffrey Mfg. Co.
* Pennsylvania Crusher Co.

Pulverizers, Refractory Material
* Bethlehem Steel Co.
* Fuller-Lehigh Co.
* Hardinge Co.

Pump Governors, Valves, etc.
(See Governors, Valves, etc., Pump)

Pumping Engines
(See Engines, Pumping)

Pumping Systems, Air Lift
* Ingersoll-Rand Co.

Pumps, Acid
Buffalo Steam Pump Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Quimby, Wm. E. (Inc.)
* Schutte & Koerting Co.
Taber Pump Co.

Pumps, Air
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Wheeler, C. H. Mfg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Ammonia
Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Vogt, Henry Machine Co.

Pumps, Boiler Feed
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Chicago Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Machinery Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Westco-Chippewa Pump Co.
* Wheeler, C. H. Mfg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Centrifugal
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Chicago Pump Co.
* Cramp, Wm. & Sons Ship & Engine Bldg. Co.
* De Laval Steam Turbine Co.
* Economy Pumping Machinery Co.
Elliott Co.
* Fairbanks, Morse & Co.
* Goulds Pumps Co. (Inc.)
* Ingersoll-Rand Co.
Lammert & Mann Co.
* Morris Machine Works
* Nordberg Mfg. Co.
* Quimby, Wm. E. (Inc.)
Taber Pump Co.
* Westco-Chippewa Pump Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Cond. & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Condensation
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Chicago Pump Co.
* Economy Pumping Machinery Co.
* Ingersoll-Rand Co.
* Quimby, Wm. E. (Inc.)
* Westco-Chippewa Pump Co.
* Wheeler, C. H. Mfg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Deep Well
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Morris Machine Works
* Westco-Chippewa Pump Co.
* Worthington Pump & Machinery Corp'n

Pumps, Dredging
* Ingersoll-Rand Co.
* Morris Machine Works

Pumps, Electric
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* Chicago Pump Co.
* Economy Pumping Machinery Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Morris Machine Works
* Nordberg Mfg. Co.
* Quimby, Wm. E. (Inc.)
Taber Pump Co.
* Westco-Chippewa Pump Co.

Pumps, Elevator
Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Westco Chippewa Pump Co.

Pumps, Filter Press
Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Westco-Chippewa Pump Co.

Pumps, Fire
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.

Pumps, Fuel Oil Service
* Bethlehem Steel Co.
* Ingersoll-Rand Co.
* Worthington Pump & Machinery Corp'n

Pumps, Hand
* Goulds Pumps (Inc.)
Taber Pump Co.

Pumps, Hydraulic
* American Fluid Motors Co.
* Farrel Foundry & Machine Co.
* Ingersoll-Rand Co.

Pumps, Hydraulic Pressure
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Morris Machine Works

Pumps, Mine
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Westco-Chippewa Pump Co.
* Worthington Pump & Machinery Corp'n

Pumps, Oil
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)
* Quimby, Wm. E. (Inc.)
Taber Pump Co.
* Westco-Chippewa Pump Co.
* Worthington Pump & Machinery Corp'n

Pumps, Oil, Force-Feed
* Goulds Pumps (Inc.)
* Lunkenheimer Co.
* Quimby, Wm. E. (Inc.)

Pumps, Oil (Hand)
* Goulds Pumps (Inc.)
* Lunkenheimer Co.
* Nugent, Wm. W. & Co. (Inc.)

Pumps, Oil, High Temperature
* Ingersoll-Rand Co.
* Quimby, Wm. E. (Inc.)

Pumps, Power
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Economy Pumping Machinery Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Westco-Chippewa Pump Co.
* Wheeler Cond. & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Rotary
* American Machine & Fdry. Co.
* Goulds Pumps (Inc.)
Lammert & Mann Co.
* Quimby, Wm. E. (Inc.)
* Schutte & Koerting Co.
Taber Pump Co.
* Worthington Pump & Machinery Corp'n

Pumps, Sewage
* Chicago Pump Co.
* Economy Pumping Machinery Co.
* Ingersoll-Rand Co.

Pumps, Steam
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Fairbanks Morse & Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Cond. & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Sugar House
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.

Pumps, Sump
Buffalo Steam Pump Co.
* Chicago Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Machinery Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Morris Machine Works
* Quimby, Wm. E. (Inc.)
* Smidth, F. L. & Co.
Taber Pump Co.

Pumps, Tank
Buffalo Steam Pump Co.
* Economy Pumping Machinery Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
Taber Pump Co.
* Westco-Chippewa Pump Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Cond. & Engrg. Co.

Pumps, Turbine
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Machinery Co.
Elliott Co.
* General Electric Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Morris Machine Works
* Westco-Chippewa Pump Co.
* Worthington Pump & Machinery Corp'n

Pumps, Vacuum
* Air Preheater Corp'n
* American Machine & Fdry. Co.
* Bethlehem Steel Co.
Buffalo Steam Pump Co.
* Chicago Pump Co.
* Croll-Reynolds Engineering Co.
* Economy Pumping Machinery Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
Lammert & Mann Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Cond. & Engrg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Water Works
* Ingersoll-Rand Co.
* Worthington Pump & Machinery Corp'n

Punches, Power
Buffalo Forge Co.
Niagara Machine & Tool Works

Punching and Coping Machines
Buffalo Forge Co.

Punching and Shearing Machines
Buffalo Forge Co.
* Schatz Mfg. Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT Alphabetical List on page 120

Purifiers, Ammonia
* Frick Co. (Inc.)
Purifiers, Oil
* De Laval Steam Turbine Co.
Elliott Co.
* Nugent, Wm. W. & Co. (Inc.)
Purifiers, Steam
Andrews-Bradshaw Co.
Purifiers, Water
* Graver Corp'n
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.
Purifying and Softening Systems, Wtear
* Graver Corp'n
* International Filter Co.
Reisert Automatic Water Purifying Co.
* Scaife, Wm. B. & Sons Co.
Pyrometers, Electric
* American Schaeffer & Budenberg Corp'n
* Bristol Co.
* Brown Instrument Co.
* Superheater Co.
* Taylor Instrument Cos.
Pyrometers, Expansion Stem
* Brown Instrument Co.
Pyrometers, Optical
* Taylor Instrument Cos.
Pyrometers, Radiation
* Brown Instrument Co.
* Taylor Instrument Cos

Racks, Machine, Cut
* Foote Bros. Gear & Machine Co.
* Horsburgh & Scott Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
Radiators, Steam and Water
* Smith, H. B. Co.
Walworth Co.
Rams, Hydraulic
* Goulds Pumps (Inc.)
Receivers, Air
* Ingersoll-Rand Co.
* Kieley & Mueller (Inc.)
* Scaife Wm. B. & Sons Co.
Struthers-Wells Co.
* Walsh & Weidner Boiler Co.
* Wheeler Cond. & Engrg. Co.
Receivers, Ammonia
* Frick Co. (Inc.)
Struthers-Wells Co.
Recorders, CO
* Brown Instrument Co.
Recorders, CO_2
* Brown Instrument Co.
Recorders, Liquid Level
* Brown Instrument Co.
Recorders, SO_2
* Brown Instrument Co.
Refinery Equipment
* Bethlehem Steel Co.
* Graver Corp'n
Refractories
* Drake Non-Clinkering Furnace Block Co.
* King Refractories Co. (Inc.)
* McLeod & Henry Co.
Refrigerating Machinery
* De La Vergne Machine Co.
* Frick Co (Inc.)
* Ingersoll-Rand Co.
Johns-Manville (Inc)
* Nordberg Mfg. Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.
Regulators, Blower
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
* Wing, L. J. Mfg. Co.
Regulators, Damper
* Brown Instrument Co.
Cutler-Hammer Mfg. Co.
* d'Este, Julian Co.
* Fulton Co.
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
Ruggles-Klingemann Mfg. Co.
Walworth Co.
* Wing, L. J. Mfg. Co.
Regulators, Electric
Allen-Bradley Co.
American Brown Boveri Elec. Corp'n
Cutler-Hammer Mfg. Co.
* General Electric Co.
Regulators, Fan Engine
* Kieley & Mueller (Inc.)
Ruggles-Klingemann Mfg. Co.
Walworth Co.
Regulators, Feed Water
* Brown Instrument Co.
* Edward Valve & Mfg. Co.
* Kieley & Mueller (Inc.)
Squires, C. E. Co.
Regulators, Flow (Steam)
* Schutte & Koerting Co.
Regulators, Humidity
* Brown Instrument Co.
* Fulton Co.
Regulators, Hydraulic Pressure
* d'Este, Julian Co.
* Mason Regulator Co.
Regulators, Liquid Level
* Brown Instrument Co.
Regulators, Pressure
* Edward Valve & Mfg. Co.
* d'Este, Julian Co.
* Fulton Co.
* General Electric Co.
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
Ruggles-Klingemann Mfg. Co.
* Taylor Instrument Cos.
Walworth Co.
Regulators, Temperature
* Bristol Co.
* Brown Instrument Co.
* d'Este, Julian Co.
* Fulton Co.
* Kieley & Mueller (Inc.)
Ruggles-Klingemann Mfg. Co
* Sarco Co. (Inc.)
* Taylor Instrument Cos.
Regulators, Vacuum
* Kieley & Mueller (Inc.)
Ruggles-Klingemann Mfg. Co.
Walworth Co.
Regulators, Voltage, Automatic
American Brown Boveri Elec. Corp'n
Relays, Electric
American Brown Boveri Elec. Corp'n
Rings, Weldless
Cann & Saul Steel Co.
Rivet Heaters, Electric
* General Electric Co.
Riveters, Pneumatic
* Ingersoll-Rand Co.
Rods, Monel Metal
* International Nickel Co.
Rods, Nickel
* International Nickel Co.
Rolling Mill Machinery
* Farrel Foundry & Machine Co.
Rolls, Bending
Niagara Machine & Tool Works
Rolls, Crushing
* Farrel Foundry & Machine Co.
* Fuller-Lehigh Co.
Rolls, Forming (Sheet Metal)
Niagara Machine & Tool Works
Rolls, Rubber
* United States Rubber Co.
Roofing
Johns-Manville (Inc.)
Roofing, Asbestos
Johns-Manville (Inc.)
Rope, Hoisting
Clyde Iron Works Sales Co.
* Roebling's, John A. Sons Co.
Rope, Transmission
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Roebling's, John A. Sons Co.
Rope, Wire
Clyde Iron Works Sales Co.
Hill Clutch Mach. & Fdry. Co.
* Roebling's, John A. Sons Co.
Rope Drives
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
Wood's, T. B. Sons Co.
Rubber Goods, Mechanical
* Jenkins Bros.
* United States Rubber Co.
Rubber Mill Machinery
* Farrel Foundry & Machine Co.
Rust Proofing
* American Machine & Fdry. Co.

Sand Blast Apparatus
* De La Vergne Machine Co.
Sash Operating Devices
Cutler-Hammer Mfg. Co.
Saw Blades, Hack
Racine Tool & Machine Co.
Saw Mill Machinery
* Allis-Chalmers Mfg. Co.
* Murray, D. J. Mfg. Co.
Saw Mills, Portable
* Frick Co (Inc.)
Sawing Machines, Metal
Racine Tool & Machine Co.
Sawing Machines, Woodworking
Racine Tool & Machine Co.
Saws, Hack (Power)
Racine Tool & Machine Co.
Scales, Automatic (For all purposes)
* Fairbanks, Morse & Co.
* Toledo Scale Co.
Scales, Coal
* Toledo Scale Co.
Scales, Computing
* Toledo Scale Co.
Scales, Continuous Sheet-Weight Indicator
* Toledo Scale Co.
Scales, Counter
* Toledo Scale Co.
Scales, Counting
* Toledo Scale Co.
Scales, Hanging
* Toledo Scale Co.
Scales, Heavy Duty
* Toledo Scale Co.
Scales, Overhead Track
* Toledo Scale Co.
Scales, Platform
* Fairbanks, Morse & Co.
* Toledo Scale Co.
Scales, Special Industrial Purposes
* Toledo Scale Co.
Scales, Suspended Platform
* Toledo Scale Co.
Scales, Tank
* Toledo Scale Co.
Screens, Perforated Metal
* Hendrick Mfg. Co.
Screens, Revolving
* Allis-Chalmers Mfg. Co.
* Chain Belt Co.
* Hendrick Mfg. Co.
* Jeffrey Mfg. Co.
* Murray, D. J. Mfg. Co.
* Smidth, F. L. & Co.
Screens, Shaking
* Allis-Chalmers Mfg. Co.
* Chain Belt Co.
* Hendrick Mfg. Co.
* Jeffrey Mfg. Co.
Screens, Water Intake (Traveling)
* Chain Belt Co.
Screw Cutting Dies
(See Dies, Thread Cutting)
Screw Machines, Hand
* Jones & Lamson Mach. Co.
Warner & Swasey Co.
Screws, Safety Set
Allen Mfg. Co.
* Bristol Co.
Screws, Set
Allen Mfg. Co.
Scrubbers, Air and Gas
Andrews-Bradshaw Co.
* Bartlett-Hayward Co.
* Murray, D. J. Mfg. Co.
Separators, Ammonia
* De La Vergne Machine Co.
Elliott Co.
* Frick Co. (Inc.)
* Vogt, Henry Machine Co.
Separators, Magnetic
Cutler-Hammer Mfg. Co.
Separators, Oil
* Bethlehem Steel Co.
* Cochrane Corp'n
* De La Vergne Machine Co.
Elliott Mfg. Co
Hoppes Mfg. Co.
* Kieley & Mueller (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry Machine Co.
Walworth Co.
Separators, Steam
* Cochrane Corp'n
Elliott Co.
Hoppes Mfg. Co.
* Kieley & Mueller (Inc.)
* Pittsburgh Valve, Fdry. & Const. Co.
* Vogt, Henry Machine Co.
Walworth Co.
Separators, Steam (Boiler Drum, Interior)
Andrews-Bradshaw Co.
Shafting
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
Cumberland Steel Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
Wood's, T. B. Sons Co.
Shafting, Cold Drawn
Hill Clutch Mach. & Fdry. Co.
* Medart Co.
Shafting, Flexible
Cooper Flexible Transmission Co.
* Gwilliam Co.
Shafting, Turned and Polished
Cumberland Steel Co.
Hill Clutch Mach. & Fdry. Co.
Shapes, Brick
* McLeod & Henry Co.
Shears, Alligator
* Farrel Foundry & Machine Co.
Shears, Rotary
Niagara Machine & Tool Works
Shears, Squaring
Niagara Machine & Tool Works
Sheaves, Rope
Brown, A. & F. Co.
Clyde Iron Works Sales Co.
* Falls Clutch & Machinery Co.
Hill Clutch Mach. & Fdry Co.
* Jones, W. A. Fdry. & Mch. Co.
* Medart Co.
* Murray, D. J. Mfg. Co.
* Nordberg Mfg. Co.
Wood's, T. B. Sons Co.
Sheet Metal Work
* Allington & Curtis Mfg. Co.
* Breese Bros. Co.
* Hendrick Mfg. Co.
Sheet Metal Working Machinery
* Farrel Foundry & Machine Co.
Niagara Machine & Tool Works
Sheets, Bronze
* Hendrick Mfg. Co.
Sheets, Monel Metal
* International Nickel Co.
Sheets, Nickel
* International Nickel Co.
Sheets, Rubber, Hard
* United States Rubber Co.
Sheets, Steel
* Bethlehem Steel Co.
Ships, Diesel, Turbine, or Electrically Driven
American Brown Boveri Elec. Corp'n
Signal System (Engine and Boiler Room)
Cutler-Hammer Mfg. Co.
Signals, Industrial Plant
Cory, Chas. & Son (Inc.)
Siphons (Steam-Jet)
* Schutte & Koerting Co.
Skein Dyeing Machines
* Franklin Machine Co.
Slide Rules
Alteneder, Theo. & Sons
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)
Smoke Recorders
* Sarco Co. (Inc.)
Soot Blowing Systems
Bayer Co.
* Diamond Power Specialty Corp'n
Special Machinery
* American Machine & Fdry. Co.
Brown, A. & F. Co.
* Builders Iron Foundry
* Cramp, Wm. & Sons Ship & Engine Bldg. Co.
* Farrel Foundry & Machine Co.
* Franklin Machine Co.
Hill Clutch Mach. & Fdry. Co.
Lammert & Mann
* Murray, D. J. Mfg. Co.
* Nordberg Mfg. Co.
* Smidth, F. L. & Co.
* Vilter Mfg. Co.
Speed Reducing Motions
* Nugent, Wm. W. & Co. (Inc.)
Speed Reducing Transmissions
* American Fluid Motors Co.
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Foote Bros. Gear & Machine Co.
* Ganschow, Wm. Co.
* General Electric Co.
Hill Clutch Mach. & Fdry. Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.
* Morse Chain Co.
* Palmer-Bee Co.
* Philadelphia Gear Works
Shepard Electric Crane & Hoist Co.
Spray Cooling Ponds
* Yarnall-Waring Co.
Spray Cooling Systems
* Cooling Tower Co. (Inc.)
* Schutte & Koerting Co.
* Yarnall-Waring Co.
Sprays, Water
* Cooling Tower Co. (Inc.)
* Schutte & Koerting Co.
* Yarnall-Waring Co.
Sprinkler Systems
Rockwood Sprinkler Co.
Sprinklers, Spray
* Cooling Tower Co. (Inc.)
Sprockets
Baldwin Chain & Mfg. Co.
* Diamond Chain & Mfg. Co.
* Foote Bros. Gear & Machine Co.
* Fuller-Lehigh Co.
Hill Clutch Mach. & Fdry. Co.
* Jeffrey Mfg. Co.
* Medart Co.
* Morse Chain Co.
* Murray, D. J. Mfg. Co.
* Philadelphia Gear Works
Stacks, Steel
* Bigelow Co.
* Casey-Hedges Co.
* Cole, R. D. Mfg. Co.
* Erie City Iron Works
* Graver Corp'n
* Heine Boiler Co.
* Hendrick Mfg. Co.

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT Alphabetical List on page 120

* Union Iron Works
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

Stair Treads
* Irving Iron Works Co.

Stair Treads, Rubber
* United States Rubber Co.

Stampings, Sheet Metal
* Liberty Electric Corporation
Rockwood Sprinkler Co.

Standpipes
* Cole, R. D. Mfg. Co.
* Fairbanks, Morse & Co.
* Graver Corp'n
* Walsh & Weidner Boiler Co.

Starters, Electric
Allen-Bradley Co.

Steam Specialties
* d'Este, Julian Co.
* Fulton Co.
* Kieley & Mueller (Inc.)
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Sarco Co. (Inc.)
* Yarnall-Waring Co.

Steel, Alloy
* Bethlehem Steel Co.
Cann & Saul Steel Co.

Steel, Bar
Cann & Saul Steel Co.

Steel, Cold Rolled
Cumberland Steel Co.

Steel, Open-Hearth
* Falk Corporation

Steel, Rock Drill
* Ingersoll-Rand Co.

Steel, Tool
Cann & Saul Steel Co.

Steel Plate Construction
* Bethlehem Steel Co.
* Bigelow Co.
* Burhorn, Edwin Co.
* Casey-Hedges Co.
* Cole, R. D. Mfg. Co.
* Erie City Iron Works
* Graver Corp'n
* Heine Boiler Co.
* Hendrick Mfg. Co.
* Keeler, E. Co.
Struthers-Wells Co.
* Union Iron Works
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

Steps, Ladder and Stair (non-Slipping)
* Hendrick Mfg. Co.
* Irving Iron Works Co.

Stills
* Bethlehem Steel Co.
Struthers-Wells Co.
* Vogt, Henry Machine Co.

Stills, Welded
Kellogg, M. W. Co.

Stocks and Dies
Walworth Co.

Stokers, Chain Grate
* Babcock & Wilcox Co
* Combustion Engineering Corp'n
* Riley Stoker Corp'n

Stokers, Overfeed
* Riley Stoker Corp'n

Stokers, Underfeed
* American Engineering Co.
* Combustion Engineering Corp'n
* Riley Stoker Corp'n
* Sturtevant, B. F. Co.

Strainers, Oil
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
* Nugent, Wm. W. & Co. (Inc.)
* Schutte & Koerting Co.

Strainers, Steam
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
* Schutte & Koerting Co.
Walworth Co.

Strainers, Water
Elliott Co.
* Kieley & Mueller (Inc.)
* Mason Regulator Co.
* Schutte & Koerting Co.
Walworth Co.

Structural Steel Fabrication
American Brown Boveri Elec. Corp'n
* Bethlehem Steel Co.

Structural Steel Work
* Bethlehem Steel Co.
* Erie City Iron Works
* Hendrick Mfg. Co.
* Walsh & Weidner Boiler Co.

Sugar Machinery
* Bartlett-Hayward Co.
* Erie City Iron Works
* Farrel Foundry & Machine Co.
Struthers-Wells Co.
* Walsh & Weidner Boiler Co.

Superheaters, Steam
* Babcock & Wilcox Co.
* Heine Boiler Co.
* Power Specialty Co.
* Superheater Co.

Superheaters, Steam (Locomotive)
* Power Specialty Co.
* Superheater Co.

Superheaters, Steam (Marine)
* Power Specialty Co.
* Superheater Co.

Switchboards
* General Electric Co.
* Liberty Electric Corporation

Switches, Electric
Allen-Bradley Co.
American Brown Boveri Elec. Corp'n
Cutler-Hammer Mfg. Co.
* General Electric Co.
* Liberty Electric Corporation

Switches, Monorail and Turntable
* Yale & Towne Mfg. Co.

Switches, Oil
American Brown Boveri Elec. Corp'n

Systems, Waste Heat Recovery
* Edge Moor Iron Co.

Tables, Drawing
Dietzgen, Eugene Co.
Keuffel & Esser Co.
* Pease, C. F. Co.
Weber, F. Co. (Inc.)

Tachometers
* American Schaeffer & Budenberg Corp'n
* Bristol Co.
Cory, Chas. & Sons (Inc.)
Veeder Mfg. Co.

Tachometers, Electric
* Brown Instrument Co.

Tachoscopes
* American Schaeffer & Budenberg Corp'n

Tank Work (Air, Gas, Oil and Water)
* Erie City Iron Works
* Heine Boiler Co.
* Scaife, Wm. B. & Sons Co.
Struthers-Wells Co.

Tanks, Acid
* Erie City Iron Works
* Graver Corp'n
Struthers-Wells Co.
* Walsh & Weidner Boiler Co

Tanks, Blow-off
* Cochrane Corp'n
* Erie City Iron Works
* Graver Corp'n
Struthers-Wells Co.

Tanks, Copper
* Breese Bros. Co.

Tanks, Ice
* Erie City Iron Works
* Frick Co. (Inc.)
* Graver Corp'n
Struthers-Wells Co.

Tanks, Oil
* Fairbanks, Morse & Co.
* Graver Corp'n
* Hendrick Mfg. Co.
* Nugent, Wm. W. & Co. (Inc.)
* Scaife, Wm. B. & Sons Co.
Struthers-Wells Co.
* Walsh & Weidner Boiler Co.

Tanks, Pressure
* Erie City Iron Works
* Graver Corp'n
* Hendrick Mfg. Co.
* Ingersoll Rand Co.
* Scaife, Wm. B. & Snos Co.
Struthers-Wells Co.
* Vogt, Henry Machine Co.
* Walsh & Weldner Boiler Co.

Tanks, Riveted
* Graver Corp'n
* Scaife, Wm. B. & Sons Co.
Struthers-Wells Co.

Tanks, Stainless Steel
Struthers-Wells Co.

Tanks, Steel
* Bethlehem Steel Co.
* Bigelow Co.
* Casey-Hedges Co.
* Cole, R. D. Mfg. Co.
* Erie City Iron Works
* Graver Corp'n
* Heine Boiler Co.
* Hendrick Mfg. Co.
* Scaife, Wm. B. & Sons Co.
Struthers-Wells Co.
* Union Iron Works
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

Tanks, Storage
* Cochrane Corp'n
* Cole, R. D. Mfg. Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* Fairbanks, Morse & Co.
* Graver Corp'n
* Hendrick Mfg. Co.
* Nugent, Wm. W. & Co. (Inc.)
* Scaife, Wm. B. & Sons Co.
Struthers-Wells Co.
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

Tanks, Tower
* Graver Corp'n
* Walsh & Weidner Boiler Co.

Tanks, Welded
* Cole, R. D. Mfg. Co.
* Graver Corp'n
Kellogg, M. W. Co.
* Scaife, Wm. B. & Sons Co.
Struthers-Wells Co.

Tap Extensions
Allen Mfg. Co.

Tapping Attachments
* Whitney Mfg. Co.

Taps and Dies
Walworth Co.

Temperature Regulators
(See Regulators, Temperature)

Testing Laboratories, Cement
* Smidth, F. L. & Co.

Textile Machinery
* Franklin Machine Co.
Tolhurst Machine Works

Textile Printing Machinery
* Franklin Machine Co.

Thermometers
* American Schaeffer & Budenberg Corp'n
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
Moto Meter Co.
* Sarco Co. (Inc.)
* Taylor Instrument Cos.

Thermometers, Dial
* American Schaeffer & Budenberg Corp'n
Moto Meter Co.

Thermometers, Distance
* Taylor Instrument Cos.

Thermometers, High Range (Recording)
* Bailey Meter Co.
* Brown Instrument Co.
* Taylor Instrument Cos.

Thermometers, Industrial
* Brown Instrument Co.

Thermometers, Long Distance
* Brown Instrument Co.

Thermometers, Recording
* American Schaeffer & Budenberg Corp'n
* Taylor Instrument Cos.

Thermostats
* Bristol Co.
* Brown Instrument Co.
* d'Este, Julian Co.
* Fulton Co.
* General Electric Co.

Tie Tamping Outfits
* Ingersoll-Rand Co.

Time Recorders
* Bristol Co.

Tinsmiths' Tools and Machines
Niagara Machine & Tool Works

Tools, Brass-Working Machine
Warner & Swasey Co.

Tools, Pneumatic
* Ingersoll-Rand Co.

Tools, Thread Cutting
* Jones & Lamson Machine Co.
Walworth Co.

Tracks, Overhead
* Palmer-Bee Co.

Tractor
* Allis-Chalmers Mfg. Co.

Tractors, Industrial (Storage Battery)
* Yale & Towne Mfg. Co.

Trailers, Industrial
* Yale & Towne Mfg. Co.

Tramrail, Systems, Overhead
Shepard Electric Crane & Hoist Co.

Tramways, Wire Rope
Clyde Iron Works Sales Co.
* Roebling's, John A. Sons Co.

Transformers, Electric
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* General Electric Co.
* Liberty Electric Corporation

Transmissions, Automobile
*Foote Bros. Gear & Machine Co.

Transmissions, Variable Speed
* American Fluid Motors Co.
* Foote Bros. Gear & Machine Co.

Traps, Radiator
* Sarco Co. (Inc.)

Traps, Return
* d'Este, Julian Co.
* Kieley & Mueller (Inc.)

Traps, Steam
* American Schaeffer & Budenberg Corp'n
* Cochrane Corp'n
* d'Este, Julian Co.
* Jenkins Bros.
Johns-Manville (Inc.)
* Kieley & Mueller (Inc.)
* Reading Steel Casting Co. (Inc.)
* Sarco Co. (Inc.)
* Schutte & Koerting Co.
Squires, C. E. Co.
* Vogt, Henry Machine Co.
Walworth Co.
* Yarnall-Waring Co.

Traps, Vacuum
* American Schaeffer & Budenberg Corp'n
* Kieley & Mueller (Inc.)
* Sarco Co. (Inc.)
* Schutte & Koerting Co.

Treads, Safety
* Hendrick Mfg. Co.
* Irving Iron Works Co.

Trolleys
Shepard Electric Crane & Hoist Co.

Trolleys, Monorail
* Palmer-Bee Co.

Trucks, Industrial (Storage Battery)
* Fairbanks, Morse & Co.
* Yale & Towne Mfg. Co.

Trucks, Trailer
* Yale & Towne Mfg. Co.

Tube Cleaners, Boiler
Walworth Co.
* Yarnall-Waring Co.

Tubes, Boiler, Seamless Steel
* Casey-Hedges Co.

Tubes, Condenser
* Wheeler Condenser & Engrg. Co

Tubes, Pitot
Bacharach Industrial Instrument Co.

Tubing, Monel Metal
* International Nickel Co.

Tubing, Nickel
* International Nickel Co.

Tubing, Rubber
* United States Rubber Co.

Tumbling Barrels
* Erie City Iron Works
* Farrel Foundry & Machine Co.

Turbines, Hydraulic
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n.
* Cramp, Wm. & Sons Ship & Engine Bldg. Co.
* De Laval Steam Turbine Co.
Hoppes Water Wheel Co.
* Leffel, James & Co.
* Smith, S. Morgan Co.

Turbines, Steam
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n.
* De Laval Steam Turbine Co.
Elliott Co.
* General Electric Co.
* Moore Steam Turbine Corp'n
Ridgway Dynamo & Engine Co.
* Sturtevant, B. F. Co.
* Terry Steam Turbine Co.
* Wheeler Condenser & Engrg. Co.
* Wing, L. J. Mfg. Co.

Turbines, Water
American Brown Boveri Elec. Corp'n
* Worthington Pump & Machinery Corp'n

Turbo-Blowers
American Brown Boveri Elec. Corp'n
Elliott Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F. Co.
* Terry Steam Turbine Co.
* Wing, L. J. Mfg. Co.

Turbo-Compressors
American Brown Boveri Elec. Corp'n
* De Laval Steam Turbine Co.
Elliott Co.
* Ingersoll Rand Co.
* Terry Steam Turbine Co.

Turbo-Generators
* Allis-Chalmers Mfg. Co.
American Brown Boveri Elec. Corp'n
* De Laval Steam Turbine Co.
Elliott Co.
* General Electric Co.
* Moore Steam Turbine Corp'n
Ridgway Dynamo & Engine Co.
* Sturtevant, B. F. Co.
* Terry Steam Turbine Co.

Turbo-Pumps
* Bethlehem Steel Co.
* De Laval Steam Turbine Co.
* Economy Pumping Machinery Co.
Elliott Co.
* Ingersoll-Rand Co.
* Moore Steam Turbine Corp'n
* Terry Steam Turbine Co.
* Wheeler Condenser & Engineering Co.

Turntables
* Bethlehem Steel Co.
* Palmer-Bee Co.

Turret Machines
(See Lathes, Turret)

Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 120

Unions
* Edward Valve & Mfg. Co.
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Vogt, Henry Machine Co.
Walworth Co.

Unions, Pressed Steel
Rockwood Sprinkler Co.

Unloaders, Air Compressor
* Ingersoll-Rand Co.
* Yarnall-Waring Co.

Unloaders, Car
* Jeffrey Mfg. Co.

Vacuum Breakers
* Kieley & Mueller (Inc.)
Ruggles-Klingemann Mfg. Co.
* Schutte & Koerting Co.

Valve Discs
* Edward Valve & Mfg. Co.
* Garlock Packing Co.
* Jenkins Bros.
* Reading Steel Casting Co. (Inc.)
* United States Rubber Co.
Walworth Co.

Valve Operating Systems (Electric Remote Control)
Cutler-Hammer Mfg. Co.
* Liberty Electric Corporation

Valves, Air, Automatic
* Fulton Co.
* Jenkins Bros.
* Simplex Valve & Meter Co.
* Smith, H. B. Co.
Walworth Co.

Valves, Air (Operating)
* Kieley & Mueller (Inc.)

Valves, Air, Relief
* American Schaeffer & Budenberg Corp'n
* Fulton Co.
* Kieley & Mueller (Inc.)
* Lunkenheimer Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

Valves, Altitude
* Kieley & Mueller (Inc.)
* Simplex Valve & Meter Co.

Valves, Ammonia
* American Schaeffer & Budenberg Corp'n
* De La Vergne Machine Co.
* Jenkins Bros.
* Kieley & Mueller (Inc.)
* Lunkenheimer Co.
* Reading Steel Casting Co. (Inc.)
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.
Walworth Co.

Valves, Back Pressure
* Cochrane Corp'n
* Jenkins Bros.
* Kieley & Mueller (Inc.)
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
Ruggles-Klingemann Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

Valves, Balanced
* d'Este, Julian Co.
* Kieley & Mueller (Inc.)
* Lunkenheimer Co.
* Mason Regulator Co.
* Nordberg Mfg. Co.
Ruggles-Klingemann Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

Valves, Blow-off
* Ashton Valve Co.
* Edward Valve & Mfg. Co.
Elliott Co.
* Jenkins Bros.
* Lunkenheimer Co.
* Murray, D. J. Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
Walworth Co.
* Yarnall-Waring Co.

Valves, Butterfly
* Chapman Valve Mfg. Co.
* Lunkenheimer Co.
* Pittsburgh Valve, Fdry. & Const. Co.
Ruggles-Klingemann Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

Valves, Check
* American Schaeffer & Budenberg Corp'n
* Chapman Valve Mfg. Co.
* Edward Valve & Mfg. Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
* Nordberg Mfg. Co.
* Pittsburgh Valve, Fdry. & Const. Co.
* Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry Machine Co.
Walworth Co.

Valves, Chronometer
* Kieley & Mueller (Inc.)
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Valves, Combined Back Pressure and Relief
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Valves, Diaphragm
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* Brown Instrument Co.
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* General Electric Co.
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* Wheeler Cond. & Engrg. Co.

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How architects and heating contractors may use a simple problem to their advantage and *profit!*

The Problem:

Why does this funnel overflow?

The Answer:

There is more water flowing in at the top than can possibly flow out through the narrow neck of the funnel at the bottom.

THERE is only one way that architects and contractors can overcome the competition of the over-rated boiler. That way is to make boiler prospects appreciate the difference in efficiency and cost of operation between a Fairly Rated Boiler having sufficient Fire Surface and an over-rated boiler which hasn't enough Fire Surface. This is a difficult thing to do but we have found a way to do it very effectively in our magazine and newspaper advertising. Architects and heating contractors can use the same method to their advantage and profit. The way we are doing it in our national advertising is by means of the simple illustration given above.

In that illustration water is being wasted because more is flowing in at the top than can possibly flow out the narrow neck at the bottom. Turning on more water will get practically no more into the bottle. Because only so much and no more water can pass through the neck of the funnel.

So with a boiler. The Fire Surface corresponds to the neck of the funnel. The heat given off by the fuel burned corresponds to the water. When there is insufficient Fire Surface heat "overflows" and is wasted up the chimney. Generating more heat by forcing the fire only means greater waste up the chimney. Because the Fire Surface, like the neck of the funnel, can absorb only so much heat and pass it into the home.

By means of this simple illustration it is very easy for the layman to visualize the fuel he will waste if he has an inefficient boiler. It is easy for him to see why, when an extra cold snap occurs, forcing an over-rated boiler will waste more fuel but give him very little, if any, more heat.

By means of this simple illustration you can prove to a prospect that if he wants comfort and heating economy he *must* have a boiler with Sufficient Fire Surface Fairly Rated.

To further help architects and heating contractors to thoroughly acquaint their clients with the economical necessity for a Fairly Rated Boiler we have issued a 32-page booklet, "The Truth about Boiler Ratings"—a valuable book for architects and heating contractors to lend to their clients. The coupon below will bring you a copy by return mail with our compliments.

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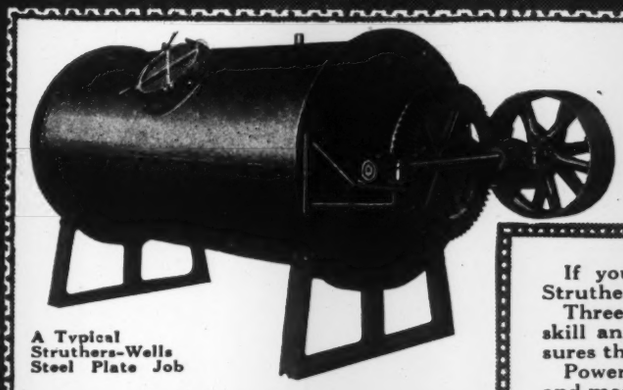

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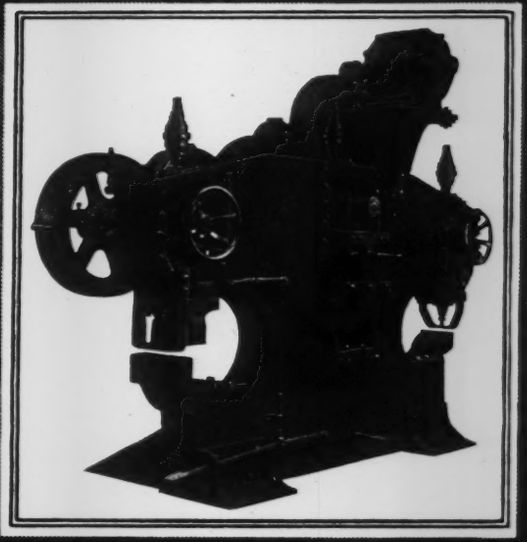
The combination punch and shear machine illustrated to the right is a typical example of Struthers-Wells foundry and machine shop facilities. These departments while primarily operated to serve the plate department of this company—have sufficient surplus available to serve other companies building special machines and machine shop products in quantities under contract.

A number of manufacturers are already taking advantage of this surplus capacity—perhaps we can serve you too.



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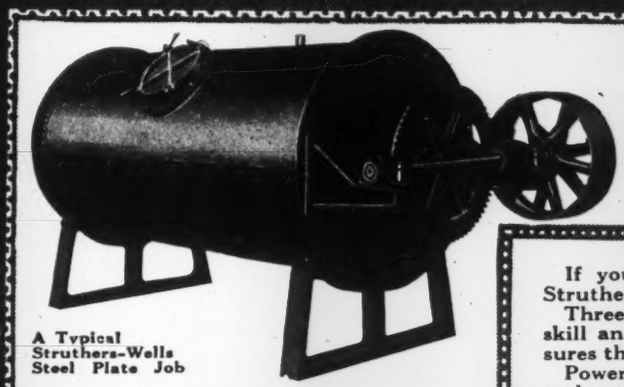
Catalogue data of firms marked appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1926-27 Volume*



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The combination punch and shear machine illustrated to the right is a typical example of Struthers-Wells foundry and machine shop facilities. These departments while primarily operated to serve the plate department of this company—have sufficient surplus available to serve other companies building special machines and machine shop products in quantities under contract.

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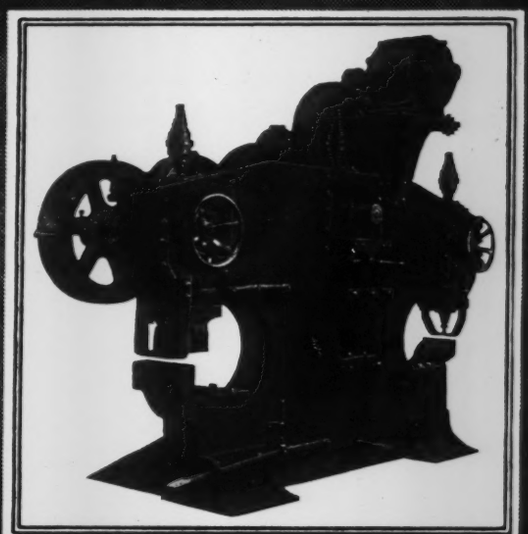

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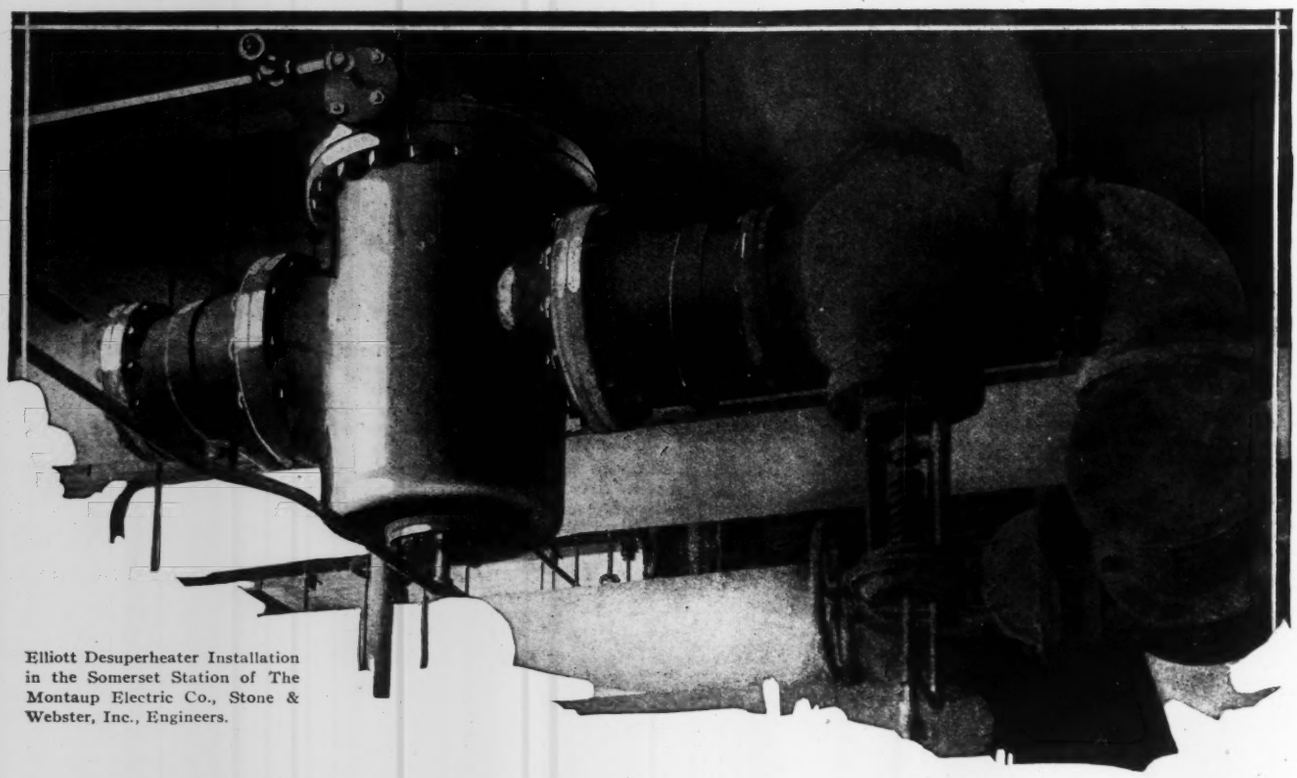

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Effective Desuperheating

Desuperheating of steam cannot be effectively accomplished simply by spraying water into the steam. It is possible for a stream of water to be flowing at the bottom of a pipe line with superheated steam passing above it.

Elliott Desuperheaters operate by inserting in the path of the steam a concentrated metal mesh cartridge which mingles water and steam, retains the water, and uniformly equalizes interchange of heat over the entire area.

Elliott Desuperheaters are successfully operating in widely different types of service. They are producing dry saturated steam with the use of a small amount of water which is easily controlled or regulated automatically. They are simple, compact, and the desuperheating cartridge is removable through the cover.

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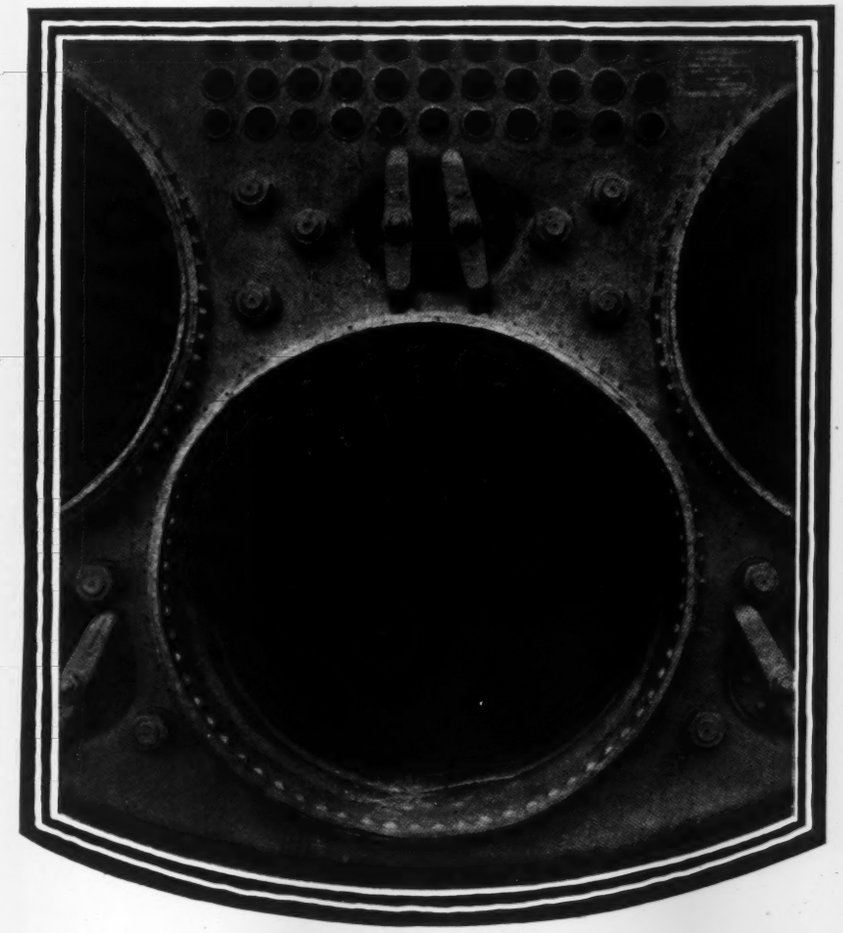

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Taylor Forge Welded Furnaces, Shells and Flues can be supplied in a range of sizes from the very smallest up to 72 inches in diameter by one inch thickness. Made of the highest grade of firebox steel. Comply with the A.S.M.E. rules and meet all the requirements of official bureaus and societies.

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This catalog describes Taylor Forged Tubular products and contains many tables of value to the engineer. Sent on request.

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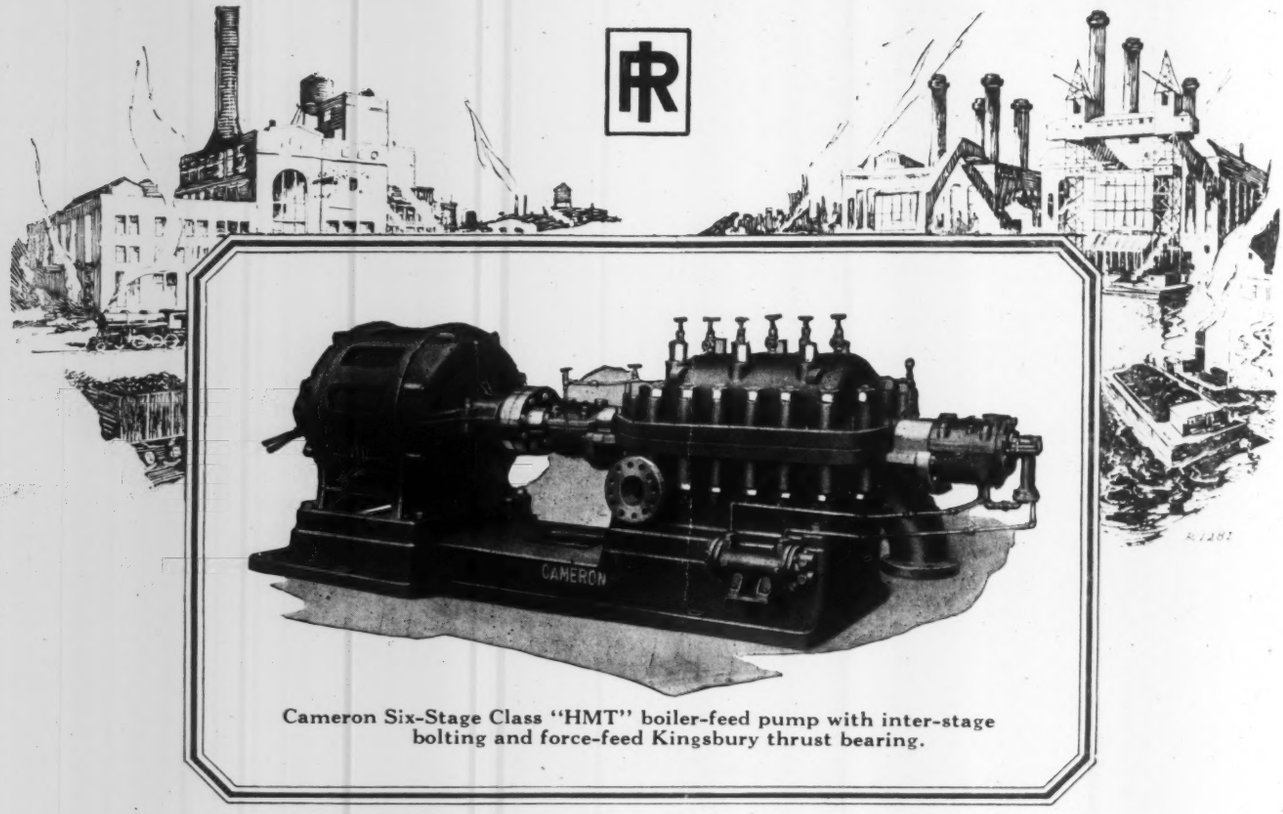

Cameron Six-Stage Class "HMT" boiler-feed pump with inter-stage bolting and force-feed Kingsbury thrust bearing.

THE pumping requirements of modern high-pressure plants have been successfully met by the Cameron organization.

Nowhere can you obtain greater dependability, greater freedom from trouble, and more substantial and durable pumps.

In central stations and in modern steam plants for high-pressure boiler feeding; in mines for high-lift drainage; in steel mills; in battleships;—wherever liquids must be pumped under high pressures, the Cameron Class "HMT" pump will be found ideal for the task.

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